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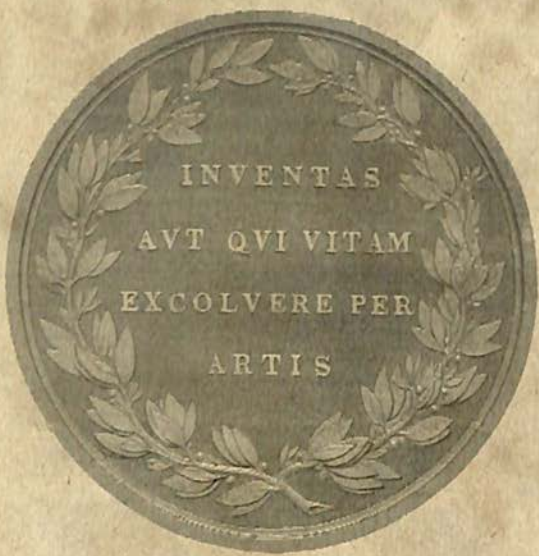

From the Medal by Pidgeon.
Struck at the Soho Mint in 1819.
Reverse.

J. Bate. sculp.

THE

ORIGIN AND PROGRESS

OF

THE MECHANICAL INVENTIONS

OF

JAMES WATT

ILLUSTRATED BY HIS CORRESPONDENCE WITH HIS FRIENDS AND THE SPECIFICATIONS OF HIS PATENTS.

52131
ac.

BY JAMES PATRICK MUIRHEAD, ESQ., M.A.

H d 25

IN THREE VOLUMES.

VOL. III.

LETTERS PATENT, SPECIFICATIONS OF PATENTS, AND APPENDIX.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
M.DCCC.LIV.

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AND CHARING CROSS.

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(BY BRANSTON.)

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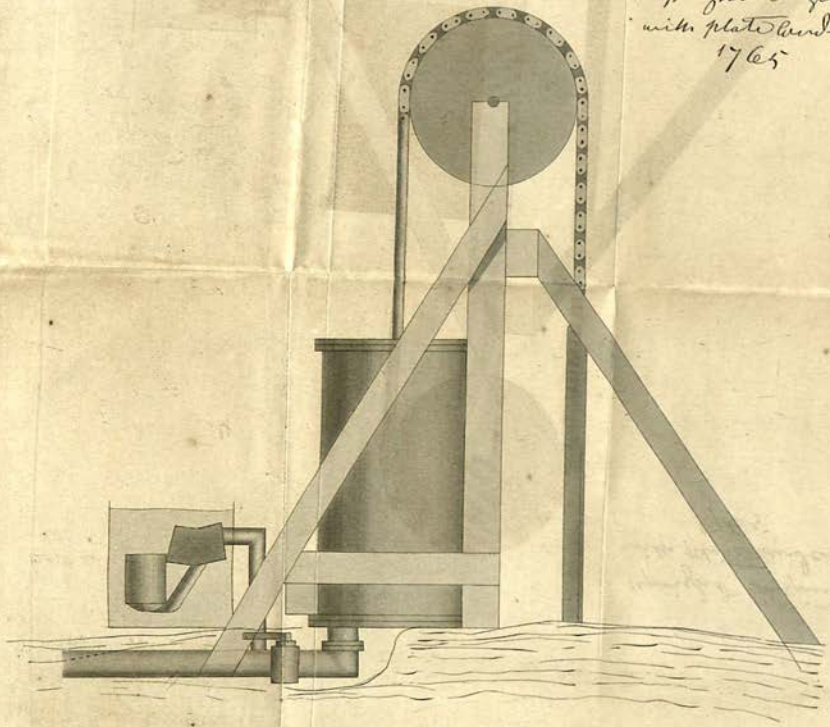
PLATE I.

upright Engine
with plate Condenser
1765



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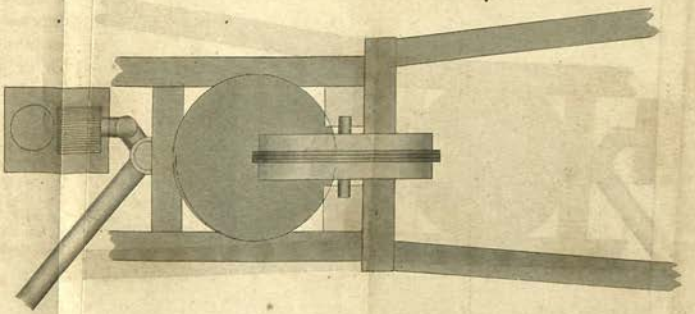
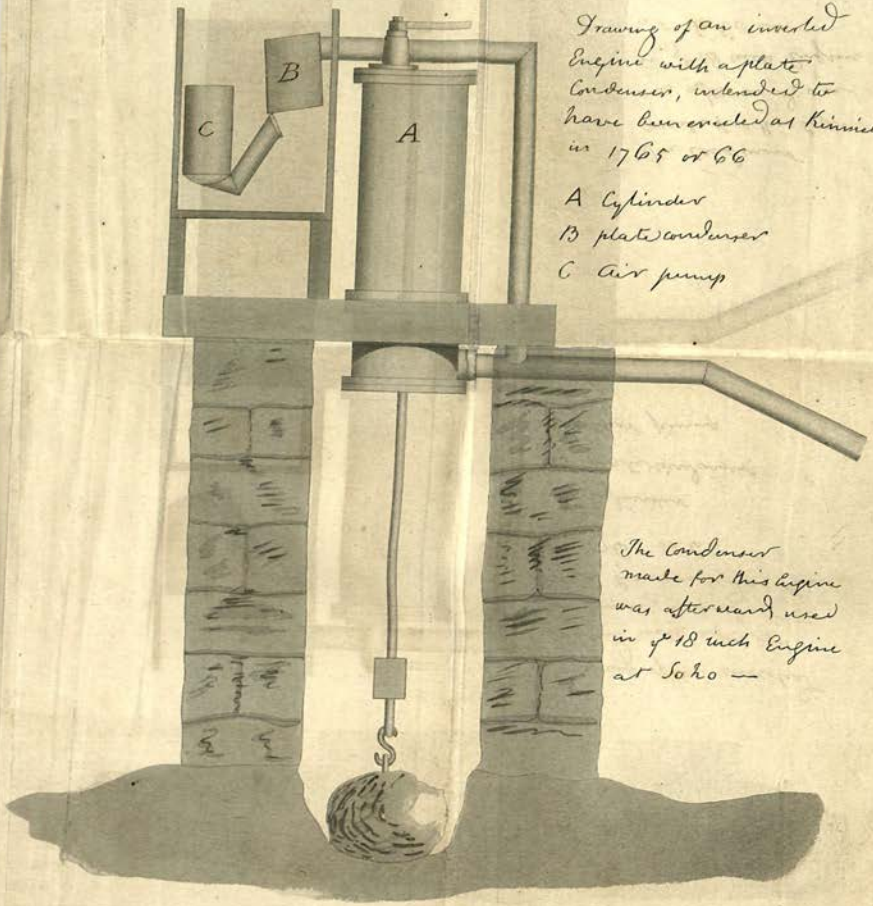
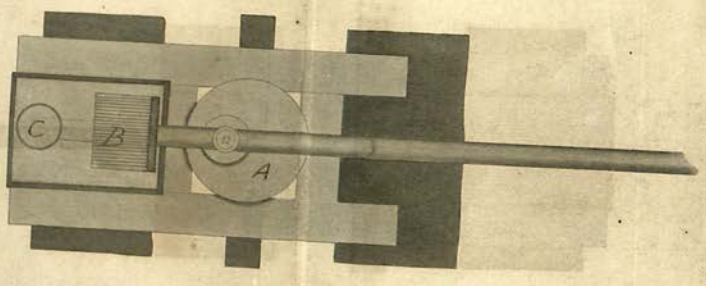


Drawing of an inverted Engine with a plate Condenser, intended to have been erected at Kinneil in 1765 or 66

A Cylinder
B plate condenser
C Air pump



The Condenser made for this Engine was afterwards used in a 18 inch Engine at Soho —



J. W. Lowry fp.

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LETTERS PATENT,

AND

SPECIFICATIONS OF PATENTS.

LETTERS PATENT, DATED JANUARY 5TH, 1769, FOR A METHOD OF LESSENING THE CONSUMPTION OF STEAM AND FUEL IN FIRE ENGINES.*

GEORGE THE THIRD, BY THE GRACE OF GOD, &c.

TO ALL TO WHOM these presents shall come, greeting:

WHEREAS JAMES WATT hath by his Petition humbly represented unto us that he hath, after much labour and expense, invented a Method of lessening the Consumption of Steam and Fuel in Fire Engines, which he apprehends will be of great Publick Utility: And in regard he is the

* These Letters Patent, as well as the Act of Parliament prolonging the duration of the exclusive privilege which they conferred, (see pp. 17-26, *infra*), are here printed as being documents of interest in the history of the steam-engine. But as one example will suffice to show the form of Letters Patent at that time, and as the Act of 1775 was the only prolongation of privilege for which Mr. Watt applied, of all the other Patents granted to him we shall give only the Specifications, (with engravings of the relative drawings).

first and true Inventor thereof, and the same hath not been practised or used by any other person or persons to his knowledge or belief, he therefore most humbly prayed us to grant unto him, his executors, administrators, and assigns, OUR ROYAL LETTERS PATENT under Our Great Seal of Great Britain, for the sole benefit and advantage of his said Invention within that part of Great Britain called England, our Dominion of Wales, and Town of Berwick upon Tweed, and also in our Colonies and Plantations abroad, for the term of Fourteen years, according to the Statute in that case made and provided: WE, being willing to give encouragement to all Arts and Inventions which may be for the Publick Good, are graciously pleased to condescend to his Request.

KNOW YE, therefore, that WE of our especial grace, certain knowledge and meer motion, Have given and granted, and by these presents for us, our heirs and successors, Do give and grant unto the said JAMES WATT, his executors, administrators, and assigns, OUR especial licence, full power, sole priviledge and authority, that he the said JAMES WATT, his executors, administrators, and assigns, and every of them, by himself and themselves, or by his and their deputy or deputys, servants or agents, or such others as he the said JAMES WATT, his executors, administrators, or assigns, shall at any time agree with, and no others, from time to time and at all times hereafter during the term of years herein expressed, shall and lawfully may make, use, exercise and vend his said Invention

within that part of our Kingdom of Great Britain called England, our Dominion of Wales, and Town of Berwick upon Tweed, and also in our Colonies and Plantations abroad, in such manner as to him the said JAMES WATT, his executors, administrators, and assigns, or any of them, shall in their discretions seem meet. AND that he the said JAMES WATT, his executors, administrators, and assigns, shall and lawfully may have and enjoy the whole profit, benefit, commodity, and advantage, from time to time coming, growing, accruing, and arising by reason of his said Invention, for and during the term of years herein mentioned: To have, hold, exercise, and enjoy the said licence, powers, priviledges, and advantages herein before granted or mentioned to be granted unto the said JAMES WATT, his executors, administrators, and assigns, for and during and unto the full end and term of Fourteen years from the date of these presents next and immediately ensuing, and fully to be compleat and ended according to the Statute in such case made and provided. AND to the end that he the said JAMES WATT, his executors, administrators, and assigns, and every of them, may have and enjoy the full benefit and the sole use and exercise of the said Invention, according to our gracious intention herein before declared, —WE do by these presents, for us, our heirs and successors, require and strictly command all and every person and persons, bodies politick and corporate, and all other our subjects whatsoever, of what estate, quality, degree, name, or condition

soever they be, within that said part of our Kingdom of Great Britain called England, our Dominion of Wales, and Town of Berwick upon Tweed, and also in all our Colonies and Plantations abroad aforesaid, that neither they nor any of them, at any time during the continuance of the said term of Fourteen years hereby granted, either directly or indirectly do make, use, or put in practice the said Invention, or any part of the same, so attained unto by the said JAMES WATT as aforesaid, nor in any wise counterfeit, imitate, or resemble the same, nor shall make or cause to be made any addition thereunto or subtraction from the same, whereby to pretend himself or themselves the Inventor or Inventors, Devisor or Devisors thereof, without the licence, consent, or agreement of the said JAMES WATT, his executors, administrators, or assigns, in writing under his or their hands and seals first had and obtained in that behalf, upon such pains and penalties as can or may be justly inflicted on such Offenders for their contempt of this Our Royal Command: AND further to be answerable to the said JAMES WATT, his executors, administrators, and assigns, according to Law, for his and their damages thereby occasioned. And moreover WE do by these presents for us, our heirs and successors, will and command all and singular the Justices of the Peace, Mayors, Sheriffs, Bailiffs, Constables, Headboroughs, and all other Officers and Ministers whatsoever of us, our heirs and successors for the time being, that they or any of them do not nor

shall at any time hereafter during the said term hereby granted in anywise molest, trouble, or hinder the said JAMES WATT, his executors, administrators, or assigns, or any of them, or his or their deputys, servants, or agents, in or about the due and lawful use or exercise of the aforesaid Invention, or anything relating thereto. PROVIDED ALWAYS, and these our Letters Patent are and shall be upon this Condition, that if at any time during the said term hereby granted it shall be made appear to us, our heirs or successors, or any six or more of our or their Privy Council, that this our Grant is contrary to Law, or prejudicial or inconvenient to our subjects in general, or that the said Invention is not a new Invention as to the publick use and exercise thereof in that said part of our Kingdom of Great Britain called England, our Dominion of Wales, and Town of Berwick upon Tweed, and our Colonies and Plantations abroad aforesaid, or not invented and found out by the said JAMES WATT as aforesaid, —Then upon Signification or Declaration thereof to be made by us, our heirs or successors, under our or their Signet or Privy Seal, or by the Lords and others of our or their Privy Council, or any six or more of them, under their hands, these our Letters Patent shall forthwith cease, determine, and be utterly void to all intents and purposes, anything hereinbefore contained to the contrary thereof in anywise notwithstanding. PROVIDED ALSO, that these our Letters Patent, or anything herein contained, shall not extend or be construed

to extend to give priviledge unto the said JAMES WATT, his executors, administrators, or assigns, or any of them, to use or imitate any Invention or Work whatsoever which hath heretofore been found out or invented by any other of our subjects whatsoever, and publickly used or exercised in that said part of our Kingdom of Great Britain called England, our Dominion of Wales, or Town of Berwick upon Tweed, or our Colonies and Plantations abroad aforesaid, unto whom like Letters Patent or priviledges have been already granted for the sole use, exercise, and benefit thereof; it being Our will and pleasure that the said JAMES WATT, his executors, administrators, and assigns, and all and every other person and persons to whom like Letters Patent or priviledges have been already granted as aforesaid, shall distinctly use and practise their several Inventions by them invented and found out, according to the true intent and meaning of the same respective Letters Patent and of these presents; provided likewise nevertheless, and these our Letters Patent are upon this express Condition, that if the said JAMES WATT, his executors or administrators, or any person or persons which shall or may at any time or times hereafter during the continuance of this grant, have or claim any right, title, or interest in Law or in Equity, of, in, or to the power, priviledge, and authority of the sole use and benefit of the said Invention hereby granted, shall make any transfer or assignment, or any pretended transfer or assignment of the said liberty

and priviledge, or any share or shares of the benefits or profit thereof, or shall declare any Trust thereof to or for any number of persons exceeding the number of five, or shall open or cause to be opened any book or books for publick subscriptions to be made by any number of persons exceeding the number of five, in order to the raising any sum or sums of money under pretence of carrying on the said liberty or priviledge hereby granted, or shall by him or themselves, or his or their agents or servants, receive any sum or sums of money whatsoever of any number of persons exceeding in the whole the number of five, for such or the like intents or purposes, or shall presume to act as a corporate body, or shall divide the benefit of these our Letters Patent, or the liberty and priviledges hereby by us granted, into any number of shares exceeding the number of five, or shall commit or do, or procure to be committed or done, any act, matter, or thing whatsoever during such time as such person or persons shall have any right or title, either in Law or Equity, in or to the said premises, which will be contrary to the true intent and meaning of a certain Act of Parliament made in the Sixth year of the Reign of our late Royal Great Grandfather, King George the First, intituled "An Act "for the better securing certain powers and privi- "ledges intended to be granted by His Majesty by "two Charters for Assurance of Ships and Mer- "chandizes at Sea, and for lending Money upon "Bottomry, and for restraining several extravagant

" and unwarrantable practices therein mentioned," —or in case the said power, priviledge, or authority shall at any time hereafter become vested in or in Trust for more than the number of five persons, or their representatives at any one time (reckoning executors or administrators as and for the single person whom they represent as to such interest as they are or shall be intituled to in right of such their testator or intestate), That then, and in any of the said cases, these our Letters Patent, and all liberties and advantages whatsoever hereby granted, shall utterly cease, determine, and become void, anything hereinbefore contained to the contrary thereof in anywise notwithstanding. PROVIDED ALSO, that if the said JAMES WATT shall not particularly describe and ascertain the nature of his said Invention, and in what manner the same is to be performed, by an instrument in writing under his hand and seal, and cause the same to be inrolled in our High Court of Chancery within four calendar months next and immediately after the date of these our Letters Patent, that then these our Letters Patent, and all liberties and advantages whatsoever hereby granted, shall utterly cease, determine, and become void, anything hereinbefore contained to the contrary thereof in anywise notwithstanding. And LASTLY, WE do by these presents, for us, our heirs and successors, Grant unto the said JAMES WATT, his executors, administrators, and assigns, that these our Letters Patent, or the Inrolment or Exemplifi-

cation thereof, shall be in and by all things good, firm, valid, sufficient and effectual in the Law, according to the true intent and meaning thereof, and shall be taken, construed, and adjudged in the most favourable and beneficial sense for the best advantage of the said JAMES WATT, his executors, administrators, and assigns, as well in all our Courts of Record as elsewhere, and by all and singular the Officers and Ministers whatsoever of us, our heirs and successors, in that part of our said Kingdom of Great Britain called England, our Dominion of Wales, and Town of Berwick upon Tweed, and also in our Colonies and Plantations abroad aforesaid, and amongst all and every the subjects of us, our heirs and successors, whatsoever and wheresoever, notwithstanding the not full and certain describing the nature or quality of the said Invention, or of the materials thereto conducing and belonging. In Witness, &c.

Witness Ourself at Westminster, the fifth day of January, in the ninth year of our reign.

BY WRITT OF PRIVY SEAL.

SPECIFICATION OF PATENT, JANUARY 5TH, 1769, FOR A NEW METHOD OF LESSENING THE CONSUMPTION OF STEAM AND FUEL IN FIRE ENGINES.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Glasgow, in Scotland, Merchant, send greeting.

WHEREAS His Most Excellent Majesty King George the Third, by his Letters Patent, under

* The greatest invention set forth in this Specification is undoubtedly that of the separate condenser; which is now so well understood, and so universally adopted, as to need no further illustration from us here. But there is another part of the specification which at the time was equally novel, and on which, as its importance has been less fully explained by writers on the steam-engine, and therefore less appreciated by the public, it may be proper to make some observations.

It has been elsewhere shown, (see above, vol. ii. p. 233, *note;* Translation of Arago's 'Eloge of Watt,' p. 66, &c. &c.), that both the contrivance imagined and delineated by Papin, and the engine executed on a large and efficient scale by Newcomen, were quite as much *atmospheric* as *steam* engines; the whole power employed being the pressure of the atmosphere, and the descent of the piston being only accelerated by a vacuum formed beneath it by the condensation of steam. The same remark applies to the engine of Savery, where the pressure of the atmosphere was applied directly to the water to be pumped up, instead of to a piston working in a barrel or cylinder.

But this was not the case with the steam-engine with a separate condenser invented by Mr. Watt. "From the first," says he, (note on Robison, p. 112), "I proposed to act upon the piston with steam "instead of the atmosphere; and my model was so constructed." He

the Great Seal of Great Britain, bearing date the fifth day of January, in the ninth year of his said Majesty's reign, did give and grant unto me, the said JAMES WATT, his special licence, full power, sole privilege and authority, that I, the said JAMES WATT, my executors, administrators, and assigns, should, and lawfully might, during the term of years therein expressed, use, exercise, and vend throughout that part of his Majesty's Kingdom of Great Britain called England, the Dominion of Wales, and Town of Berwick upon Tweed, and also in his Majesty's Colonies and Plantations abroad, my new invented "METHOD OF LESSEN-"ING THE CONSUMPTION OF STEAM AND FUEL IN "FIRE ENGINES;" in which said recited Letters

also says that he proposed to employ the steam itself as the acting power to press on the piston, as a greater security against cooling the cylinder, as well as to keep the piston tight. The great increase of power which was thus obtained, to those who are acquainted with the elastic force of steam, will stand in need of no demonstration.

But the employment of steam instead of the atmosphere to press on the piston, implied the adaptation of a lid or top to the steam-vessel or cylinder, through an opening in which the piston-rod should work. It also involved the necessity of the piston fitting steam-tight to the inner wall or side of the cylinder; as well as of the piston-rod, (which had previously been made square, but was now to be made cylindrical), fitting with equal accuracy to the opening, collar, or *stuffing-box*, through which it worked. The difficulties which, chiefly from want of exact workmanship in the construction of the different parts, and partly from the penetrating force of the fluid with which he had to do, Mr. Watt encountered in properly *packing* the piston, as well as in preserving the tightness of the valves, &c., he has fully detailed in his correspondence. Nor was the apprehension of the magnitude and gravity of such difficulties confined to him. "At the period of "the construction of the first steam-engine upon his principles at "Soho," said the late Mr. Boulton, "the intelligent and judicious "Smeaton, who had been invited to satisfy himself of the superior

Patent is contained a Proviso, obliging me, the said JAMES WATT, by writing under my hand and seal, to cause a particular description of the nature of the said invention to be inrolled in his Majesty's High Court of Chancery, within four calendar months after the date of the said recited Letters Patent, as in and by the said Letters Patent and the Statute in that behalf made, relation being thereunto respectively had, may more at large appear:

NOW KNOW YE, that in compliance with the said Proviso, and in pursuance of the said Statute, I, the said JAMES WATT, do hereby declare that the following is a particular description of the nature of my said invention and the manner in which the same is to be performed (that is to

" performance of the engine by his own experiments upon it, and had " been convinced of its great superiority over Newcomen's, doubted the " practicability of getting the different parts executed with the requisite " precision; and augured, from the extreme difficulty of attaining this " desideratum, that this powerful machine, in its improved form, " would never be generally introduced. Such was at that period the " low state of the mechanic arts, as fully to justify his opinion; but " a school of workmen, in every relevant branch, was speedily and " successfully instituted, and the forms and construction of the " machine were perfected with a skill and accuracy till then unknown " in the execution of large machinery."—(Speech in 1824, Appendix to the Translation of the 'Eloge of Watt,' p. 195.)

It has been already mentioned, (see 'Introductory Memoir,' vol. i. p. cc. *supra*), that no drawing was annexed to this specification of 1769. To the reader, however, plate i. of the present volume, giving a view of two of the earliest experimental engines with separate condenser,—the one with an upright, and the other with an inverted cylinder,—made in 1765 and 1766, will compensate for that omission; which was an intentional one on the part of Mr. Watt and his advisers, and the reasons for which have been fully explained by us in that part of the 'Introductory Memoir' to which reference has just been made.

say): MY METHOD of lessening the consumption of steam, and consequently fuel, in fire engines, consists of the following principles:

FIRST, that vessel in which the powers of steam are to be employed to work the engine, which is called the *Cylinder* in common fire engines, and which I call the *Steam-Vessel*, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by inclosing it in a case of wood, or any other materials that transmit heat slowly; secondly, by surrounding it with steam or other heated bodies; and, thirdly, by suffering neither water nor any other substance colder than the steam to enter or touch it during that time.

SECONDLY, in Engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them: these vessels I call *Condensers*; and, whilst the engines are working, these condensers ought at least to be kept as cold as the air in the neighbourhood of the engines, by application of water, or other cold bodies.

THIRDLY, whatever air, or other elastic vapour, is not condensed by the cold of the condenser, and may impede the working of the engine, is to be drawn out of the steam vessels or condensers by means of pumps, wrought by the engines themselves, or otherwise.

FOURTHLY, I intend in many cases to employ

the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner as the pressure of the atmosphere is now employed in common fire engines: in cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the open air after it has done its office.

FIFTHLY, where motions round an axis are required, I make the steam vessels in form of hollow rings, or circular channels, with proper inlets and outlets for the steam, mounted on horizontal axles, like the wheels of a water-mill; within them are placed a number of valves, that suffer any body to go round the channel in one direction only: in these steam vessels are placed weights, so fitted to them as entirely to fill up a part or portion of their channels, yet rendered capable of moving freely in them by the means hereinafter mentioned or specified. When the steam is admitted in these engines, between these weights and the valves, it acts equally on both, so as to raise the weight to one side of the wheel, and by the re-action on the valves successively, to give a circular motion to the wheel, the valves opening in the direction in which the weights are pressed, but not in the contrary: as the steam vessel moves round, it is supplied with steam from the boiler, and that which has performed its office may either be discharged by means of condensers, or into the open air.

SIXTHLY, I intend, in some cases, to apply a degree of cold not capable of reducing the steam

to water, but of contracting it considerably, so that the engines shall be worked by the alternate expansion and contraction of the steam.

LASTLY, instead of using water to render the piston, or other parts of the engines, air and steam-tight, I employ oils, wax, resinous bodies, fat of animals, quicksilver, and other metals, in their fluid state.

IN WITNESS whereof I have hereunto set my hand and seal this twenty-fifth day of April, in the year of our Lord one thousand seven hundred and sixty-nine.

JAMES WATT.

Sealed and delivered in the presence of

COLL. WILKIE.
GEO. JARDINE.
JOHN ROEBUCK.

BE IT REMEMBERED, that the said JAMES WATT doth not intend that anything in the Fourth Article shall be understood to extend to any engine where the water to be raised enters the steam vessel itself, or any vessel having an open communication with it.*

JAMES WATT.

Witnesses. COLL. WILKIE.
GEO. JARDINE.

* This Memorandum was added by Mr. Watt, to prevent it being supposed that he had any intention of claiming the principle of Savery's engine, in which the water was raised by the elastic force of steam, but without the intervention of a piston.

INROLLED the twenty-ninth day of April, in the year of our Lord one thousand seven hundred and sixty-nine.*

* The usual term of fourteen years of exclusive privilege was afterwards extended, by Act of Parliament, (15th George III. Chap. 61, 1775), to twenty-five years from the passing of that Act, and the patent right extended to Scotland during a like term, although the original patent was only for England, Wales, Berwick on Tweed, and the colonies, as above recited, and Mr. Watt had not obtained any patent for Scotland. See pp. 17 to 26.

ANNO REGNI DECIMO QUINTO GEORGII III. REGIS.

CAP. LXI.

AN ACT FOR VESTING IN JAMES WATT, ENGINEER, HIS EXECUTORS, ADMINISTRATORS, AND ASSIGNS, THE SOLE USE AND PROPERTY OF CERTAIN STEAM ENGINES, COMMONLY CALLED FIRE ENGINES, OF HIS INVENTION, DESCRIBED IN THE SAID ACT, THROUGHOUT HIS MAJESTY'S DOMINIONS, FOR A LIMITED TIME.

Preamble.

WHEREAS His Most Excellent Majesty King George the Third, by His Letters Patent, under the Great Seal of Great Britain, bearing date the fifth day of January, in the ninth year of his reign, did give and grant unto JAMES WATT, of the city of Glasgow, Merchant, his executors, administrators, and assigns, the sole benefit and advantage of making and vending certain engines, by him invented, for lessening the consumption of steam and fuel in fire engines within that part of his Majesty's Kingdom of Great Britain called England, the Dominion of Wales, and the Town of Berwick upon Tweed, and also in his Majesty's Colonies and Plantations abroad, for the term of fourteen years; with a Proviso obliging the said JAMES WATT, by writing under his hand and seal, to cause a particular description of the nature

His Majesty's Letters Patent granted to James Watt recited.

of the said invention to be inrolled in His Majesty's High Court of Chancery, within four months after the date of the said recited Letters Patent:

AND WHEREAS the said JAMES WATT did, in pursuance of the said Proviso, cause a particular description of the said engine to be inrolled in the said High Court of Chancery, upon the twenty-ninth day of April, in the year of our Lord one thousand seven hundred and sixty-nine, which description is in the words and form, or to the effect following; that is to say,

MY METHOD of lessening the consumption of steam, and consequently fuel, in fire engines, consists of the following principles:

Specification of the Fire Engine.

FIRST, That vessel in which the powers of steam are to be employed to work the engine, which is called the *Cylinder* in common fire engines, and which I call the *Steam Vessel*, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by enclosing it in a case of wood, or any other materials that transmit heat slowly; secondly, by surrounding it with steam, or other heated bodies; and, thirdly, by suffering neither water, nor any other substance colder than the steam, to enter or touch it during that time.

SECONDLY, In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; these vessels I call *Condensers*; and, whilst the engines are

working, these condensers ought at least to be kept as cold as the air in the neighbourhood of the engines, by application of water, or other cold bodies.

THIRDLY, Whatever air or other elastick vapour is not condensed by the cold of the condenser, and may impede the working of the engine, is to be drawn out of the steam vessels or condensers by means of pumps, wrought by the engines themselves, or otherwise.

FOURTHLY, I intend in many cases to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner as the pressure of the atmosphere is now employed in common fire engines; in cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the open air after it has done its office; [which fourth article the said JAMES WATT declares, in a note affixed to the specification of the said engine, should not be understood to extend to any engine where the water to be raised enters the steam vessel itself, or any vessel having an open communication with it].

FIFTHLY, Where motions round an axis are required, I make the steam vessels in form of hollow rings, or circular channels, with proper inlets and outlets for the steam, mounted on horizontal axles, like the wheels of a water-mill; within them are placed a number of valves, that suffer any body to go round the channel in one direction only; in these steam vessels are placed weights,

so fitted to them as entirely to fill up a part or portion of their channels, yet rendered capable of moving freely in them, by the means hereinafter mentioned or specified: When the steam is admitted in these engines, between these weights and the valves, it acts equally on both, so as to raise the weight to one side of the wheel, and by the re-action on the valves, successively, to give a circular motion to the wheel, the valves opening in the direction in which the weights are pressed, but not in the contrary; as the steam vessel moves round, it is supplied with steam from the boiler, and that which has performed its office may either be discharged by means of condensers, or into the open air.

SIXTHLY, I intend, in some cases, to apply a degree of cold, not capable of reducing the steam to water, but of contracting it considerably, so that the engines shall be worked by the alternate expansion and contraction of the steam.

LASTLY, Instead of using water to render the piston or other parts of the engines air and steam-tight, I employ oils, wax, resinous bodies, fat of animals, quicksilver, and other metals, in their fluid state.

AND WHEREAS the said JAMES WATT hath employed many years, and a considerable part of his fortune, in making experiments upon steam, and steam engines, commonly called fire engines, with a view to improve those very useful machines, by which several very considerable advantages over the common steam engines are

acquired: but upon account of the many difficulties which always arise in the execution of such large and complex machines, and of the long time requisite to make the necessary trials, he could not complete his intention before the end of the year one thousand seven hundred and seventy-four, when he finished some large engines as specimens of his construction, which have succeeded so as to demonstrate the utility of the said invention:

AND WHEREAS, in order to manufacture these engines with the necessary accuracy, and so that they may be sold at moderate prices, a considerable sum of money must be previously expended in erecting mills, and other apparatus; and as several years, and repeated proofs, will be required before any considerable part of the publick can be fully convinced of the utility of the invention, and of their interest to adopt the same, the whole term granted by the said Letters Patent may probably elapse before the said JAMES WATT can receive an advantage adequate to his labour and invention:

AND WHEREAS, by furnishing mechanical powers at much less expense, and in more convenient forms, than has hitherto been done, his engines may be of great utility in facilitating the operations in many great works and manufactures of this kingdom; yet it will not be in the power of the said JAMES WATT to carry his invention into that complete execution which he wishes, and so as to render the same of the highest utility to the

publick of which it is capable, unless the term granted by the said Letters Patent be prolonged, and his property in the said invention secured, not only within that part of Great Britain called England, the Dominion of Wales, the Town of Berwick upon Tweed, and his Majesty's Colonies and Plantations abroad, but also within that part of Great Britain called Scotland, for such time as may enable him to obtain an adequate recompence for his labour, time, and expence:

TO THE END, therefore, that the said JAMES WATT may be enabled and encouraged to prosecute and complete his said invention, so that the public may reap all the advantages to be derived therefrom in their fullest extent, may it please Your Most Excellent Majesty (at the humble petition and request of the said JAMES WATT) that it may be enacted,

Sole Privilege of making, &c. said Engines vested in James Watt, his Executors, &c. for 25 Years.

AND BE IT ENACTED, by the King's Most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, that, from and after the passing of this Act, the sole privilege and advantage of making, constructing, and selling the said engines, herein-before particularly described, within the Kingdom of Great Britain, and his Majesty's Colonies and Plantations abroad, shall be, and are hereby declared to be, vested in the said JAMES WATT, his executors, administrators, and assigns, for and during the term of twenty-five years; and that the said JAMES WATT,

his executors, administrators, and assigns, and every of them, by himself and themselves, or by his and their deputy or deputies, servants or agents, or such others as he the said JAMES WATT, his executors, administrators, and assigns, shall at any time agree with, and for no others, from time to time, and at all times, during the term of years herein-before mentioned, shall and lawfully may make, use, exercise, and vend the said engines, within the Kingdom of Great Britain, and in his Majesty's Colonies and Plantations abroad, in such manner as to him the said JAMES WATT, his executors, administrators, and assigns, shall in their discretions seem meet; and that the said JAMES WATT, his executors, administrators, and assigns, shall and lawfully may have and enjoy the whole profit, benefit, commodity, and advantage, from time to time coming, growing, accruing, and arising, by reason of these his said inventions, for the said term of twenty-five years, to have, hold, receive, and enjoy the same, for and during and to the full end and term of twenty-five years as aforesaid; and that no other person or persons within the Kingdom of Great Britain, or any of his Majesty's Colonies or Plantations abroad, shall, at any time, during the said term of twenty-five years, either directly or indirectly, do, make, use, or put in practice, the said inventions, or any part of the same, so attained unto by the said JAMES WATT as aforesaid, nor in anywise counterfeit, imitate, or resemble the same; nor shall make, or cause to be made, any addition thereunto, or

subtraction from the same, whereby to pretend himself or themselves the inventor or inventors, devisor or devisors thereof, without the licence, consent, or agreement of the said JAMES WATT, his executors, administrators, or assigns, in writing under his or their hand and seal, or hands and seals, first had and obtained in that behalf, upon such pains and penalties as can or may be justly inflicted on such offenders for their contempt of this Act; and further, to be answerable to the said JAMES WATT, his executors, administrators, and assigns, according to law, for his and their damages thereby occasioned.

This Act not to extend to hinder any Person from making or using any Fire Engine, &c. which is not the present Invention of the said James Watt.

PROVIDED ALWAYS, and be it hereby declared, that nothing in this Act contained shall extend, or be construed to extend, to prejudice or hinder any person or persons from making or using any fire or steam engine, or any particular contrivance relating to the same, which is not at present of the invention of the said JAMES WATT, or which has been publickly used or exercised by any other person or persons before the time of the date of the said Letters Patent herein recited; but that all such engines and contrivances which are not at present of the said invention of the said JAMES WATT, or are not particularly specified in this Act, shall be and remain to the publick, and to the respective inventors thereof, as if this Act had never been made, anything herein contained to the contrary notwithstanding.

Proviso.

PROVIDED ALSO, that every objection in law competent against the said patent shall be competent

against this Act to all intents and purposes, except so far as relates to the term hereby granted.

PROVIDED ALWAYS, that if the said JAMES WATT, his executors, administrators, or assigns, or any person or persons who shall at any time, during the said term of twenty-five years, have or claim any right, title, or interest, in law or equity, of, in, or to the power, privilege, or authority, of the sole use and benefit of the said invention, shall make any transfer or assignment, or pretended transfer or assignment, of the said liberty or privilege hereby granted, or any share or shares of the benefit or profits thereof; or shall declare any trust thereof to or for any number of persons exceeding the number of five, or shall open, or cause to be opened, any book or books for public subscriptions, to be made by any number of persons exceeding the number of five, in order to the raising any sum or sums of money, under pretence of carrying on the said liberty or privilege hereby granted; or shall by him or themselves, or his or their agents or servants, receive any sum or sums of money whatsoever, of any number of persons exceeding in the whole the number of five, for such or the like intents or purposes; or shall presume to act as a corporate body; or shall divide the benefit of the liberty or privileges hereby granted, into any number of shares exceeding the number of five; or shall commit or do, or procure to be committed or done, any act, matter, or thing whatsoever, during such time as such person or persons shall have any right or

The Privileges granted by this Act not to be transferred to more than five Persons;

title, either in law or equity, which shall be contrary to the true intent and meaning of an Act of Parliament, made in the sixth year of the reign of His late Majesty King George the First, intituled, "An Act for the better securing certain "Powers and Privileges intended to be granted "by His Majesty, by Two Charters, for Assurance "of Ships and Merchandises at Sea, and for "lending Money upon Bottomry, and for re-"straining several extravagant and unwarrant-"able Practices therein mentioned;" or in case the said power, privilege, or authority, shall at any time become vested in or in trust for more than the number of five persons, or their representatives, at any one time, otherwise than by devise or succession, (reckoning executors and administrators as and for the single persons whom they represent, as to such interest as they are or shall be entitled to in right of such their testator or intestate); that then, and [in] every of the said cases, all liberties and advantages whatsoever hereby granted shall utterly cease, determine, and become void; anything herein-before contained to the contrary thereof in anywise notwithstanding.

on Penalty of forfeiting the same.

Public Act.

AND BE IT FURTHER ENACTED by the authority aforesaid, that this Act shall be adjudged, deemed, and taken to be a public Act; and shall be judicially taken notice of as such by all judges, justices, and other persons whomsoever, without specially pleading the same.

SPECIFICATION OF PATENT, FEBRUARY 14TH, 1780, FOR A NEW METHOD OF COPYING LETTERS AND OTHER WRITINGS EXPEDITIOUSLY.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Birmingham, in the county of Warwick, Engineer, send greeting.

WHEREAS His Most Excellent Majesty King George the Third, by his Letters Patent, under

* The first idea of this invention is believed to have originated in Mr. Watt's mind from his perception of the advantages of a scheme proposed by Dr. Darwin, of a sort of duplex pen which he called a bigrapher, but which we are not aware that there is any great reason for supposing to have been very successfully employed in practice. His bigrapher perhaps resembled that notable "instrument for writing "many copies of the same thing at once," contrived and patented by Sir William Petty in 1648, which "when it came to be tried was "found to take considerably more than twice the time to produce its "two copies that the common pen took to produce one."—('Romance 'of the Peerage,' vol. iv. p. 258-9.)

To Dr. Darwin accordingly was sent one of the early intimations of the completion of the modern copying-machine, (see vol. ii. No. [175], p. 115, *supra*), together with a specimen of the result of the process; which its inventor amused himself by supplying to others of his correspondents, as having been mysteriously done, like the magical typography of Fust, "*Non Atramento aut Plumali* "*Cannâ, sed Arte quâdam Novâ;*" (see vol. ii. No. [180], p. 121, *supra*).

The difficulty of finding materials suitable in all respects to the new process, led Mr. Watt to make a great number of experiments, especially in regard to the ink which was fittest to be used in order to insure clearness and durability in the copy, without injury to the original; and finding that the time consumed by that long series of

the Great Seal of Great Britain, bearing date at Westminster, the fourteenth day of February, in the twentieth year of his reign, did give and grant unto me, the said JAMES WATT, my exe-

trials interfered inconveniently with his other not less urgent occupations, he assumed as partners in the copying-press business both Mr. Boulton, (who was at the expense of the patent), and their mutual friend Mr. Keir, another of the members of the "Lunar Society," possessed of an active and well-informed mind, and whom his own inclinations had led to the study of chemistry and the application of it to the arts. That the manufacture of the copying-presses prospered under their joint management, is attested by the number of public, mercantile, and other offices, as well as of private individuals, that were supplied with those useful implements; which have, indeed, been ever since considered in this country as indispensable to the rapid, easy, and safe transaction of business in every extensive concern.

To the inventor this ingenious contrivance brought its own reward:—for he says in writing to one of his correspondents, (to Mr. H. B. Way, 27th March, 1809),—"It is gratifying that you find the "copying-machine useful to you. It has been so much so to me for "the last twenty-six years that it has been worth all the trouble I "had with it, had it been attended with no other profit."

"The greatest part" of the secret, he wrote to Dr. Black, (2nd December, 1779, vol. ii. No. [176], p. 115, *supra*), "resides in the "mechanical manœuvre." It is hardly necessary that we should here describe the simple process, so well understood at the present day, of exposing the letter to be copied, interleaved with damp unsized copying-paper and oiled paper, or pasteboard, to pressure for a few seconds between the rollers of a rolling-press; or, in fact, to any adequate and equable pressure, not too powerful; so that the ink may be duly impressed on the copy without being also forced through the letter-paper so as to injure the appearance of the letter. The machines manufactured for this purpose by James Watt and Co. (under which firm the Soho copying business was conducted), were, with hardly an exception, made with rollers; at first of lignum-vitæ, but afterwards of iron; the wood having been found, from the alternations of damp and dryness, to have a tendency to crack or split. By other manufacturers in later times, a screw or lever-press has been frequently substituted for rollers, as occupying less room; and this circumstance has sometimes led to comparisons being instituted between what has been called Mr. Watt's copying-press on the one hand, and what has

cutors, administrators, and assigns, his especial licence, full power, sole privilege, and authority, that I, the said JAMES WATT, my executors,

been called the modern one on the other, not always to the advantage of the former, on account of its greater bulk and weight.

It was, however, also proposed by Mr. Watt in his specification, to use, instead of a rolling-press, *a screw-press*, "or any other pressure "sufficient" for the purpose; and in the screw-press delineated in the drawing which accompanied it, (plate ii. fig. 3), will at once be recognised what, under a variety of forms and unimportant modifications, is in fact the common modern copying-press. But it will still, we think, be found, that the rollers, when properly managed, do their work more effectually than the screw; and that Mr. Watt's preference of them in his own practice was therefore not unfounded.

On the immense utility of the contrivance it is quite unnecessary to enlarge; but we may observe that for copying drawings,—a purpose for which, though expressly specified, it has, we believe, been in general but seldom used,—its merits are quite as great as for that to which it is more commonly applied. The drawing being made, as writings ought to be, with ink sufficiently mucilaginous for the purpose, the copy can be taken either on the common transparent copying-paper, or on unsized drawing-paper;—in the latter case, the copy being reversed as the impression of an engraved plate, care must be taken that any letters of reference, or descriptive titles, are not added to either the original or the copy until after the latter has been thrown off. For this purpose, pressure between rollers is decidedly preferable to that obtained by the screw.

In the great establishment at Soho, it has been the practice, by the aid of this convenient invention of its great founder, to retain copies of the drawings of all the engines sent out from that manufactory.

To this short notice of the copying-machine we have only to add, that the late Mr. James Watt, jun., having, in the course of his extensive business correspondence and frequent absence from home, felt the inconvenience of separation from so useful an assistant in the labours of the bureau as the machine thus invented by his father, contrived an extremely convenient portable form of it. In it, small brass rollers are used instead of the larger and more ponderous iron ones; and the whole apparatus, with a full supply of stationery, &c., is commodiously arranged in a travelling desk of mahogany, little more than a foot square, and not above six inches high. The exact dimensions of one now before us are $13\frac{1}{2} \times 11\frac{1}{2}$ inches; height 5 inches.

administrators, and assigns, should, and lawfully might, during the term of years therein expressed, make, use, exercise, and vend within that part of Great Britain called England, his Dominion of Wales, and Town of Berwick upon Tweed, my "INVENTION OF A NEW METHOD OF COPYING "LETTERS AND OTHER WRITINGS EXPEDITIOUSLY;" in which said recited Letters Patent is contained a Proviso, obliging me, the said JAMES WATT, by an instrument in writing, under my hand and seal, to cause a particular description of the nature of my said invention, and in what manner the same is to be performed, to be inrolled in his Majesty's High Court of Chancery within four calendar months next and immediately after the date of the said Letters Patent, as in and by the said Letters Patent, relation being thereunto had, may more at large appear.

NOW KNOW YE, that in compliance with the said Proviso, I, the said JAMES WATT, do hereby declare, that the nature of my said invention, and the manner in which the same is to be performed, is particularly described and ascertained, in manner and form following, that is to say:

Let the letter, or other writing that is intended to be copied, be written with the ink hereinafter described, or with any other writing ink fit for the purpose. Take a piece or pieces of thin paper which contain no size, or glue, or gummy or mucilaginous matter, or which at least does not contain so much size or other matter as would make it fit for being written upon. Cut this

Fig. 1st.

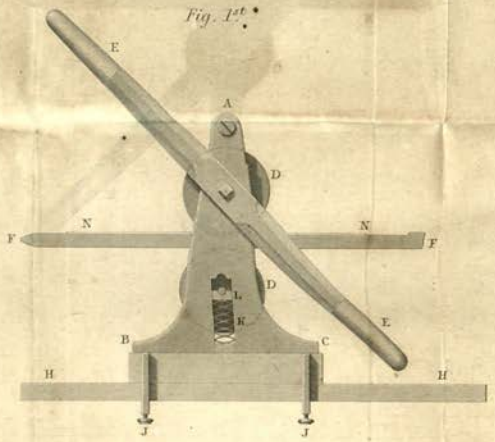


Fig 2d.

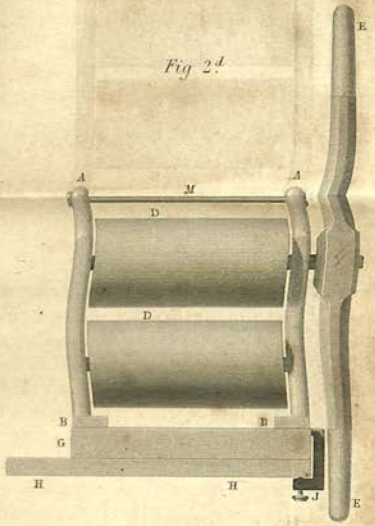
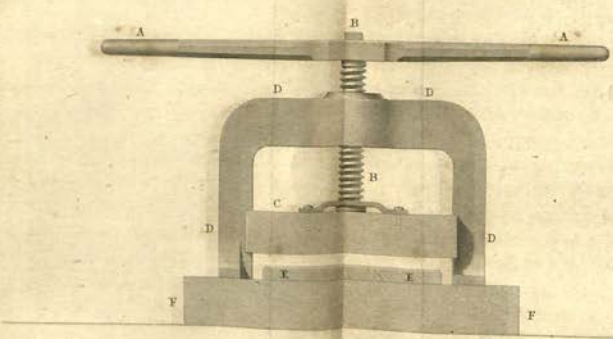


Fig. 3d.

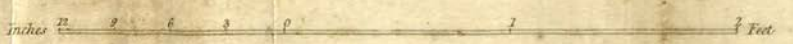


J.W. Lowry fc

The drawing Fig. 1st represents a Front or end View of the Rolling Press invented by me and referred to in the above specification. A.B.C. is one of the ends of an Iron or Wooden Frame which serves to connect the two Rollers. D.D. are two wooden or metalline Rollers turned extremely exact, or truely Cylindrical, and which are mounted on Iron Axles firmly fixt in them. E.E. is a double ended Lever, by means of which the Roller on whose Axle it is applied may be forcibly turned round. F.F. represents the Board of the Rolling Press on which the writings to be copied are to be laid. N.N. is a piece of Cloth or other elastic pliable substance placed next the Roller and above the writings to be copied, and the board. G. is a strong plank of wood or plate of metal serving to connect the two end pieces of the frame at Bottom. H.H. represents the edge of a common table to which the Press may be fastened by the Iron Screw Gramps J.J. K is a slitt, of which there is one in each end piece of the frame, these slitts are filled with elastic steel, or other metalline springs, or with some other elastic substances, which serve to press the two Rolls forcibly together. L. is a Brass Bolster, supported upon the springs, and serving to support the end of the axis of the under Roller.

The Drawing Fig. 2d represents a side view of the Rolling Press, in which A.B. A.B. are the two end pieces of the frame. D.D. are the two Rollers. E is the double ended Lever. G is the strong plank or Plate of metal which forms the bottom of the Frame. H.H. is the table on which the Press stands. J. is one of the Iron Gramps which fasten the Press to the table, and M. is a Barr of Iron which connects the upper part of the frame.

Fig. 3d represents a screw Press which may be used instead of the Rolling Press in taking off impressions from writings. A.A. is a double ended Lever. B.B. The Screw, C. a block of wood or metal, which the screw acts upon, and which is attached to it. D.D. the frame of the Press made of Iron or wood. E.E. a moveable board, on which the writing to be copied is to be laid with a cloth over it. F.F. the Bottom or Sole of the press made of wood or metal. Be it remembered that these Presses are made of different sizes according to the sizes or largeness of the writings intended to be copied. Those drawn above are drawn from one sufficiently large to take an impression from a folio page of writing on Post Paper, and are drawn to a scale of one inch and a half for each foot, or one eighth of their natural Size.



John Murray, Albemarle Street, London, 1854.

paper or papers to the size and shape of the writing of which a copy is wanted. Moisten or wet the said thin paper with water, or other liquid, by means of a sponge or brush, or by dipping, or otherwise. Having moistened or wet the thin paper, lay it between two thick unsized spongy papers, or between two cloths, or other substances capable of absorbing the superfluous moisture from the thin paper. When it has been slightly pressed between such thick spongy paper, or other substances, by the hand or otherwise, lay the said thin paper, so moistened and pressed, upon or under the side of the writing which is to be copied, and in such manner that the one side of the said moistened paper shall be in contact all over the side of the said writing so intended to be copied; and that to the other side of the said moistened thin paper there shall be applied a piece of clean writing paper or cloth, or other smooth uniform substance. Lay the said writing intended to be copied with the thin moistened paper intended to receive the copy, placed respectively as above directed, upon the board of a common rolling-press, or of that of which a description and drawing are hereunder written and drawn, and pass them once, or oftener, through the rolls of the said press, in the same manner as is used in printing by copper plates; or instead of using the said, or any other rolling-press, squeeze the said papers, placed respectively in the manner above described, in a screw press, or subject them to any other pressure sufficient for the purpose, by means of which

pressure, in whatever manner applied, part of the ink of the writing intended to be copied shall pass from the said writing into, upon, and through the said thin moistened paper, so that a copy of the said writing, more or less faint according to the quality of the ink and paper employed, shall appear impressed on both sides of the said moistened paper, viz. upon one of the sides in the natural or proper order and direction of the lines as they are in the original writing, and on the other side in the reverse order and direction. But in order to make the impression or copy of the writing more strong, legible and durable, it is proper and useful to moisten the said thin paper which is to receive the copy or impression with the following liquor, instead of water or other liquid, and to proceed in all other respects as is above directed. Or to moisten the said thin paper with the following liquor, and to dry the said paper, and when a copy of a writing is required to be taken, the said paper, thus previously prepared and dried, ought to be moistened with water or other liquid, and to be proceeded with in all other respects as has been directed. The said liquor to be used for moistening the said thin paper, or for preparing the said paper previously to its being used, is made in the following manner: Take of distilled vinegar two pounds weight, dissolve in it one ounce of the sedative salt of borax; then take four ounces of oyster shells, calcined to whiteness and carefully freed from their brown crust, put them into the vinegar, shake the

mixture frequently for four and twenty hours; then let it stand until it deposits its sediment. Filter the clear part through unsized paper into a glass vessel; then add to the said mixture or solution two ounces of the best blue Aleppo galls, bruised, and place the liquor in a warm place, shaking it frequently for twenty-four hours. Then filter the liquor again through unsized paper, and add to it after filtration one quart, ale measure, of distilled or other pure water. It must then stand twenty-four hours, and be filtered again if it shows a disposition to deposit any sediment, which it generally does. The liquor thus compounded and prepared is to be used as has been directed.

N.B.—In place of the vinegar, any other liquor impregnated with a vegetable acid may be used; and in place of the galls, oak bark, or any other vegetable astringent substance which is capable of becoming black or deep coloured with solutions of iron; and in place of the oyster shells, any other pure calcareous earth may be used. But if the impressions are not wanted to be very black, and the writing ink is good, water itself may be used to moisten the thin paper, as herein first directed. It may be found necessary to add more or less water in the preparation of the above liquor to be used for moistening the thin paper, or to vary the proportions of the other ingredients according as they are more or less perfect or strong, or as the impression is required to be more or less deep coloured. The writing ink which I use for letters

or writings intended to be copied, is prepared as follows: Take four quarts, ale measure, of spring water; one pound and a half, avoirdupois weight, of Aleppo galls; half a pound of green copperas, or green vitriol; half a pound of gum-arabic; four ounces of roach allum; pound the solid ingredients, and infuse them in the water six weeks, or two months, during which time the liquor should be frequently shaken. Strain the liquor through a linen cloth, and keep it in bottles closely corked for use.

IN WITNESS whereof, I have hereunto set my hand and seal, the twenty-second day of May, in the year of our Lord one thousand, seven hundred, and eighty.

JAMES WATT.

Sealed and delivered, being first duly stamped, in the presence of

JOSEPH PIPER.
WILLIAM PLAYFAIR.

Acknowledged by the above-named JAMES WATT at Birmingham aforesaid, this twenty-second day of May; in the year of our Lord one thousand, seven hundred, and eighty, before me,

GEO. HOLLINGTON BARKER,
A Master in Chancery Extraordinary.

INROLLED in His Majesty's High Court of Chancery, the thirty-first day of May, in the year

of our Lord 1780, being first duly stamped according to the tenor of the Statutes made in the sixth year of the reign of their late Majesties King William and Queen Mary, and in the seventeenth year of the reign of His Majesty King George the Third.

3. P. Y. THO. BRIGSTOCK.

SPECIFICATION OF PATENT, OCTOBER 25TH, 1781, FOR CERTAIN NEW METHODS OF APPLYING THE VIBRATING OR RECIPROCATING MOTION OF STEAM OR FIRE ENGINES, TO PRODUCE A CONTINUED ROTATIVE OR CIRCULAR MOTION ROUND AN AXIS OR CENTRE, AND THEREBY TO GIVE MOTION TO THE WHEELS OF MILLS OR OTHER MACHINES.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Birmingham, in the county of Warwick, Engineer, send greeting.

WHEREAS His Most Excellent Majesty King

* The application for this patent, for new methods of producing a rotative motion from a reciprocating one in the steam-engine, and thereby giving motion to mill-work, was rendered necessary by the difficulties experienced in working the steam-wheels or rotatory engines, such as that described in the specification of 1769; and by Mr. Watt having been unfairly anticipated by Wasborough, &c., in the application of the crank. No fewer than five different methods are enumerated, by any one of which the proposed end might be attained without the intervention of a crank; all of them admitting, as mentioned in the specification, of many varieties. The fifth is that commonly known as the "Sun and Planet wheels."

To all of the five methods which it describes, where heavy wheels or swift motions are not otherwise necessary for the uses to which the methods are to be applied, the specification recommends that a fly-wheel should be applied to equalise the motion. But, as Mr. Watt has observed, his application of the double engine, (described in the specification of 1782), to those rotative machines, rendered unnecessary the counter-weight, and produced a more regular motion; "so that," he says, "in most of our great manufactories these engines now supply "the place of water, wind, and horse mills; and, instead of carrying

George the Third, by His Letters Patent under the Great Seal of Great Britain, bearing date at

" the work to the power, the prime agent is placed wherever it is most " convenient to the manufacturer."—(Notes to Robison, p. 135.)

" From the time of the first invention of the improved engines," (Mr. Watt writes to his son, 10th November, 1808), " I was desirous of " applying them to giving motion to mills in some better way than by " raising water to turn a water-wheel. One method I described in the " patent," (i. e. of 1769): " the reason why that method was not pur- " sued, it is now unnecessary to enter upon. Of another method I " made a model soon after, which still exists in an unfinished state, " and several more have since been devised by myself and others. " All these were self-acting rotative engines, not derived from the " rectilinear motion of a piston in a cylinder. They have their re- " spective merits; but instead of being more simple in their construction, " they are more complex than those derived from reciprocating motions, " and more difficult in execution.

" The first I know of, of the latter kind, was one I saw at Hartley " Colliery about 1768, which consisted of a toothed sector on the end " of the working-beam, working into a trundle, which, by means of " two pinions with ratchet wheels, produced a rotative motion in the " same direction, by both the ascending and descending stroke of the " arch; and by shifting the ratchets the motion would be reversed at " pleasure, when one of the ratchets was arrived at the bottom. It was " employed to draw coals out of a pit, had no fly-wheel, and went " sluggishly and irregularly; the name of the inventor I have long " since forgotten. One Stewart had a patent for an engine which pro- " duced a rotative motion, by a chain going round a pulley and round " two barrels furnished with ratchet wheels, with a weight suspended " to the free end of the chain, which served to continue the motion " during the return of the engine. I have never seen this, but believe " there was no fly. Whether this was the same as Mr. Clarke's or " not, I know not. The next I know of is Matthew Wasborough's, " which was virtually the same as that I saw at Hartley, but Matthew " *had added a fly-wheel*, which, as far as I know, was the first time " that had been employed for that purpose. I at present recollect " nothing of Fitzgerald's rotative engine, but think it was something " of the ratchet kind.

" The true inventor of the crank rotative motion was the man, " (who unfortunately has not been deified), that first contrived the " common foot-lathe." (In another letter to his son about the same date, Mr. Watt says, " The real inventor of the rotative motion was

Westminster, the twenty-fifth day of October, in the twenty-second year of his reign, did give and

" the man, be he Chinese, Indian, Arabian, Greek, or Goth, who first " made a common foot-lathe. The applying it to the engine was " merely taking a knife to cut cheese which had been made to cut " bread.") " My share in the application I remember perfectly to " have been as follows:—One of Matthew Wasborough's rotative " engines was erected at Birmingham, for a rolling-mill, and was much " talked of. This set me again to think upon the subject, and brought " to my remembrance my former meditations upon the crank, the " date of which I cannot ascertain." (It appears to have been at all events prior to 1771, for early in that year Mr. Watt writes:—" I " have at times had my thoughts a good deal upon the subject, but " have not hit upon anything decisive: only in general it appears to " me that a crank of a sufficient sweep will be by much the sweetest " motion, and perhaps not the dearest, if its durability be considered." (See No. [90.], vol. ii. p. 17, *supra*.) " I was, however, desirous to " render the motion continued and equable without a fly-wheel, the " regulating power of which I did not then fully appreciate, nor the " advantage to be derived to the engine from the crank causing the " motion of the engine to be slow at the beginning and end of the " stroke; which, however, a few experiments with other contrivances " soon made me sensible of. I then resolved to adopt the crank; and " to equalise the power I proposed to adopt two cylinders acting upon " two cranks fixed upon the same axis at an angle of 120 from each " other, and to place a weight on the circumference of the fly-wheel at " an angle of 120 from each of the cranks; which weight was to be " so adjusted as to act when neither of the cranks could do so, and " consequently to render the power in itself nearly equable. Or to " place the two cranks at right angles to each other, and to load the " outer end of the working beams of the two cylinders with weights " equal to half the power of the respective cylinders; which might " act during the time of the ascents of the respective pistons.

" Of this I caused a model to be made, which performed to satisfac- " tion. But, being then very much engaged with other business, I " neglected to take a patent immediately, and having employed a " blackguard of the name of Cartwright, (who was afterwards hanged), " about this model, he, when in company with some of the same sort " who worked at Wasborough's mill, and were complaining of its " irregularities and frequent disasters, told them he could put them " in a way to make a rotative motion which would not go out of order " nor stun them with its noise, and accordingly explained to them what

grant unto me, the said JAMES WATT, my executors, administrators, and assigns, His especial licence, full power, sole privilege and authority, that I, the said JAMES WATT, my executors, administrators, and assigns, should, and lawfully might, during the term of years therein expressed, make, use, exercise, and vend, within that part of his Majesty's Kingdom of Great Britain called England, his Dominion of Wales, and Town of Berwick upon Tweed, my invention of "CERTAIN "NEW METHODS OF APPLYING THE VIBRATING OR

"he had seen me do. Soon after which, John Steed, who was en-
"gineer at Wasborough's mill, took a patent for a rotative motion
"with a crank, and applied it to their engine. Suspicions arising of
"Cartwright's treachery, he was strictly questioned, and confessed his
"part in the transaction when too late to be of service to us. I had
"afterwards a conversation with Steed upon the subject, who said
"that he had made the invention before he was informed of Cart-
"wright's communication, and had taken his ideas from the common
"foot-lathe; and that Cartwright's information had no other effect
"than to accelerate his taking out the patent. How this was, I know
"not; it is certainly possible that Steed might have invented it;
"but what I have related is the fact as far as concerns my in-
"vention.

"Finding the door thus closed upon us, and circumstances making
"us unwilling to go to law with the patentees, which could only have
"had the effect of throwing the invention open to the public if we had
"succeeded, we judged it better to let it remain with them,—who did
"not seem capable of doing us much harm,—than to let it get into the
"hands of men more ingenious, being sensible at the same time that
"their rotative motion could not do much good, without it were
"attached to our engines. We therefore thought it better to take a
"patent for several contrivances on the same principle, which the
"former patentees never thought proper to call in question. The
"revolving wheels was the one which we principally adopted; but the
"advantages of the crank in point of simplicity have made it now
"to be generally used, and the other to be laid aside, perhaps for
"ever."

" RECIPROCATING MOTION OF STEAM OR FIRE ENGINES, TO PRODUCE A CONTINUED ROTATIVE OR CIRCULAR MOTION ROUND AN AXIS OR CENTRE, AND THEREBY TO GIVE MOTION TO THE WHEELS OF MILLS OR OTHER MACHINES;" in which said recited Letters Patent is contained a Proviso obliging me, the said JAMES WATT, by an instrument in writing, under my hand and seal, to cause a particular description of the nature of my said invention, and in what manner the same is to be performed, to be inrolled in His Majesty's High Court of Chancery within four calendar months next and immediately after the date of the said Letters Patent, as in and by the said Letters Patent, relation being thereunto had, may more at large appear:

NOW KNOW YE, That in compliance with the said Proviso, I the said JAMES WATT do hereby declare that the nature of my said invention, and the manner in which the same is to be performed, is particularly described and ascertained in manner and form following (that is to say): the Fire or Steam Engines whose vibrating or reciprocating motions are to be converted into rotative motions by any or all of the five methods hereinafter described, may be constructed either upon the principles of the steam engines called Newcomen's Fire or Steam Engines, (which have been hitherto most commonly used), or, more advantageously, upon the principles of those newly improved steam or fire engines of my invention, (the sole use and property of which was granted to me by his present

Majesty's Royal Letters Patent, dated in the ninth year, and by an Act of Parliament made and passed in the fifteenth year of his reign); or the said engines may be constructed in any other manner or mode wherein a piston or any other part of the said steam or fire engine has a vibrating, alternating, or reciprocating motion: therefore, as for the aforesaid purpose no peculiar construction is required in those parts of the steam or fire engines which concur in and are necessary for the producing the power or active force of the engine, and its vibratory or reciprocating motion, and as steam or fire engines are common and well known machines, it is not necessary to enter into any description of them; I proceed to explain my said newly invented methods of applying the vibrating or reciprocating motions of steam or fire engines to produce a continued rotative or circular motion round an axis or centre, and thereby to give motion to the wheels of mills and other machines, which methods are five in number, and are described as followeth:

In the First of these Methods I employ the power of the steam engine, either directly, or by the intervention of a lever or levers, to pull, push, or press a friction wheel or pulley against the lateral surface of a wheel fixed obliquely upon the primary axis, shaft, or wheel which is to receive the rotative motion; which lateral surface of the said oblique or inclined wheel is represented by the section of a hollow cylinder A B C in the

drawing, No. 1, figure 1st,* cut or sawn off at the angle of sixty-five degrees to its axis, or at any other angle which may be convenient or useful; and the said friction wheel or pulley J is impelled or pulled by the power of the steam engine against the said lateral surface of the inclined wheel A C, in a direction which is in one way parallel to the said primary axis or shaft D E of the said obliquely cut cylinder or inclined wheel A C; therefore the friction wheel J, commencing its motion at the lowest or nearest part C of the said inclined wheel A C, continues to move in the aforesaid direction nearly parallel in one way to the primary shaft or axis D E, and thereby obliges the inclined wheel A C and the primary axis D E to turn round or revolve on their centre until the highest or most distant part A of the said oblique surface of the inclined wheel A C comes into contact with the said friction wheel J, at which point or time the working beam P P, or other moving part of the steam engine, has moved the length of its stroke, and is disposed to return by the common or other machinery used for that purpose, and the inclined wheel or obliquely cut cylinder A B C has made one-half of a revolution on its axis, and the rotative motion of the said inclined wheel A B C is continued in the same direction through the other half revolution by means of the descent of the heavy arch G, which was raised by the power of the steam engine at the same time with the friction

* See Plate iii., figure 1st.

PLATE III.

Drawing N.° I. relative to the First Method

Fig. 2.d

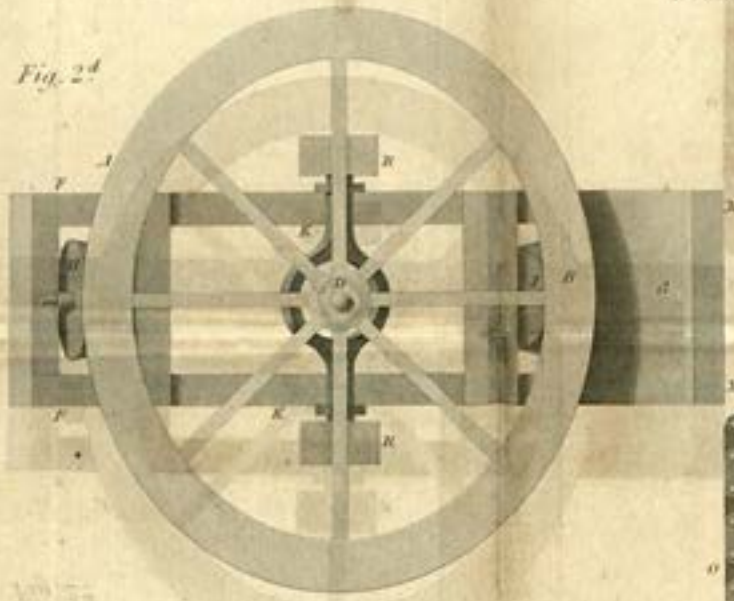


Fig. 1.st

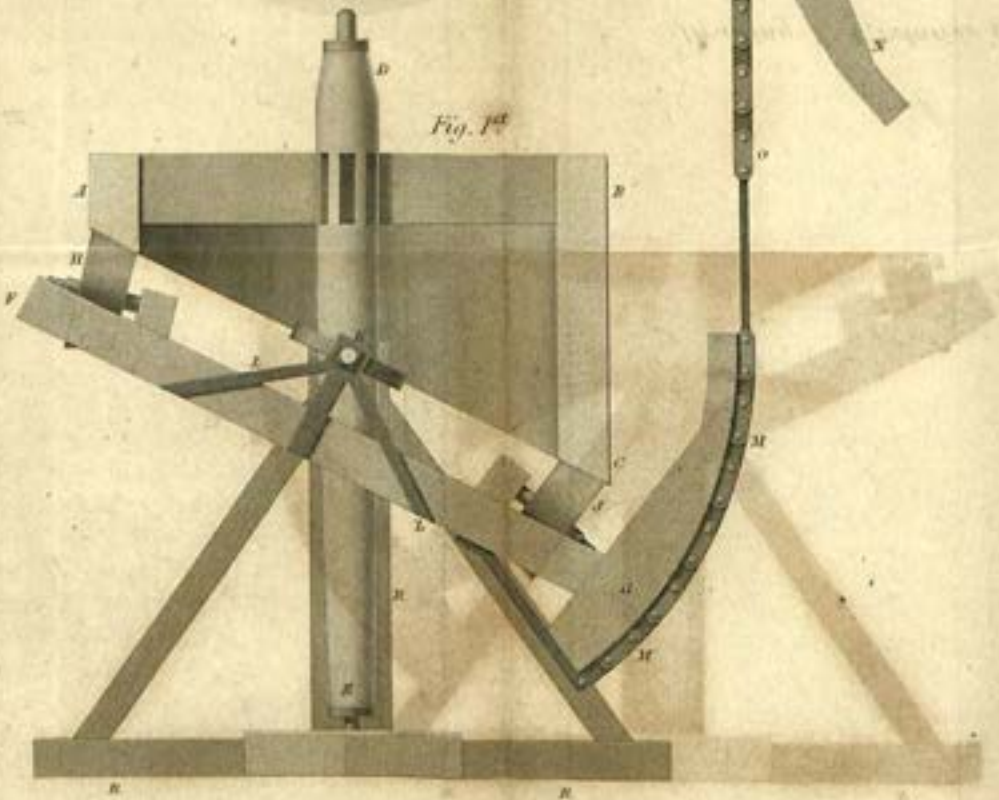
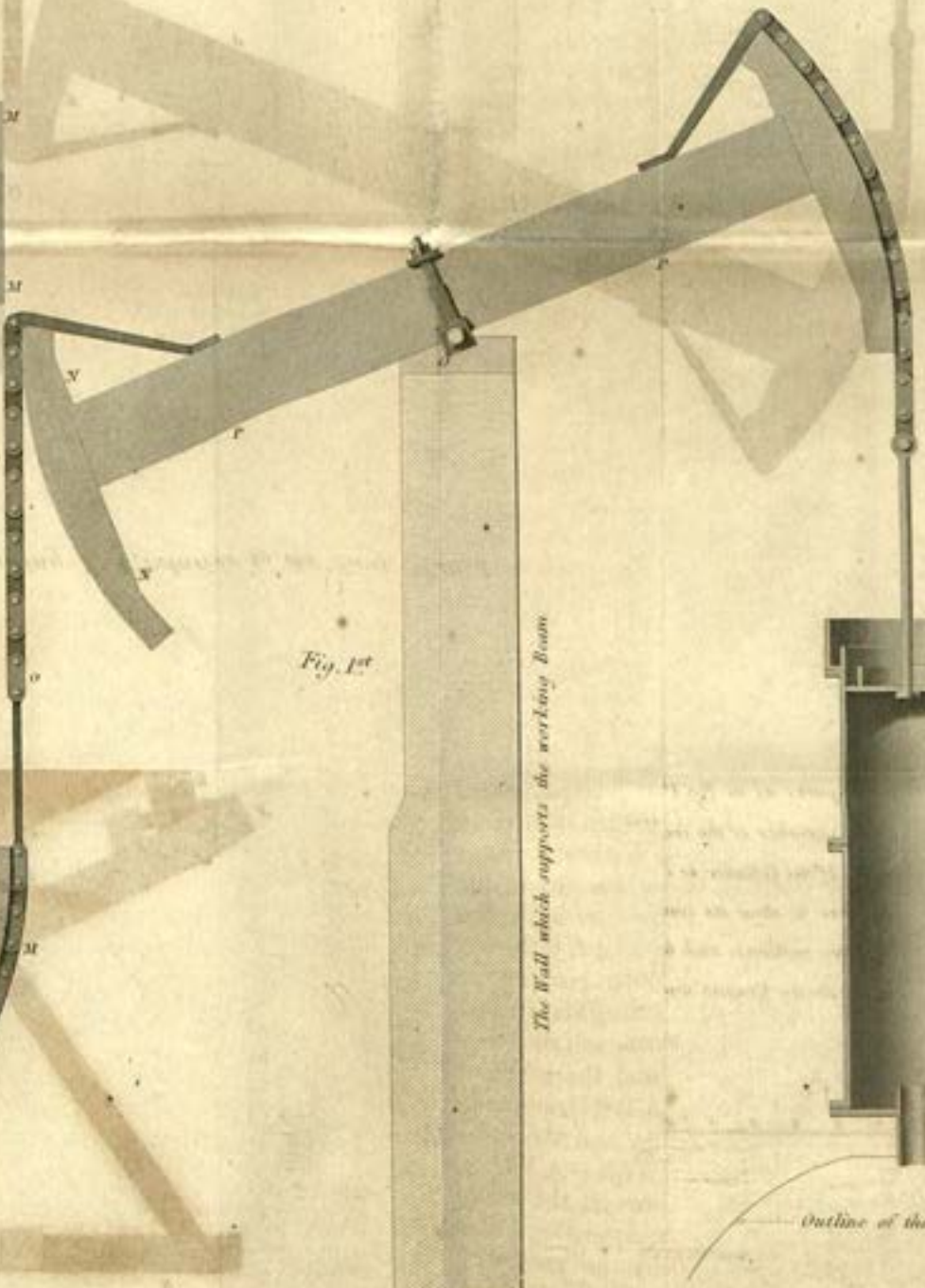


Fig. 1.st



The Wall which supports the working Beam

Outline of the Boiler Top

Fig. 1st An upright Section of the Machine.

A.B.C. The hollow Cylinder cut obliquely. D.E. The primary Axis or Shaft which is to receive the rotative motion. F.G. The Frame or Carriage. H.I. The Friction Wheels or Pulleys. K. The Axis or Centre on which the carriage moves to which it is suspended by the Iron work L.L. G.M.M. An arch of heavy matter (described from the centre K) O.O. Chains which connect the arch M.M. with the arch of the Working Beam of the Steam Engine. N.N. P.P. The working Beam of the Engine. Q. Its Axis or Gudgeon. R.R. One side of the framing which supports the axis K of the Carriage.

Fig. 2nd a Ground Plan of the oblique Cylinder and of the Carriage. The same Letters refer to the same parts as in Fig. 1st and R.R are the tops of the uprights of the framing.

N.B. In Fig. 1st the Cylinder is one of Newcomens Steam Engines to show its connection with any of these Rotative motions: and in the like manner any other Steam Engine may be connected with them

Inches 0 6 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet

J.W. Lowry fc.

wheel J, and which, during the returning motion of the working beam of the steam engine, acts upon the inclined wheel A C on the opposite side of the primary axis D E by means of a second friction wheel H, which is carried by a double lever or carriage G F, whose centre of motion is at K, and to the one end of which the heavy arch G, or any other weight, is attached or suspended, and the velocity which the matter of the wheel or cylinder A B C has acquired serves to continue its rotative motion past the points A and C, where neither the steam engine nor the weight G have much action upon it; and when the point C has again come into contact with or has passed the friction wheel J, the steam engine again commences its action, and the motion is continued, as has been recited, and the mill-work or other machinery which is required to be wrought by this machine is put in motion by the said primary axis, or by the oblique or inclined wheel, or by means of wheels connected with them in the usual manner. This method of producing a rotative motion by means of a friction wheel acting against the lateral surface of a wheel inclined to its axis, admits of many varieties in its mode of application. For I fix the primary axis or shaft either perpendicular or horizontal, or at any other angle of inclination to the horizon which may be required; and I use one or more friction wheels, and I increase or diminish the angle of inclination of the oblique wheel to the primary axis, as the case may require: as therefore I cannot herein

represent all those varieties, I have hereunto annexed a drawing or delineation and description of one of the best,* (which is applicable to the moving of corn and other similar mills), which drawing is delineated in its true proportions, according to a scale of one-fourth of an inch for each foot of the real machine, being one forty-eighth part of the real size. But it must be remembered that I make the machines larger or lesser, and vary the proportions of their parts, as their uses may require. To shew the easiest method of connecting the said new machinery with the piston of the steam or fire engine, on whatever principle it may otherwise be constructed, I have delineated in red† the piston and cylinder of a Newcomen's steam engine, (as being the most commonly used). And as the same mode of connection serves equally for all the four following methods herein described, I have not repeated the drawing of the said steam engine, but have only delineated the parts which in these methods connect the new machinery with the old.

My Second Method of producing the aforesaid rotative motion consists in applying the power of the steam engine to pull, push, or press a friction wheel or wheels against the external or internal circumference of a circular, oval or double spiral

* See Plate iii., figures 1st and 2nd.

† Viz., the piston and cylinder in Plate iii., figure 1st, shaded black in the engraving.

PLATE IV

Drawing N° 2d relative to the second Method
First Part

Fig 1st

Fig 2d

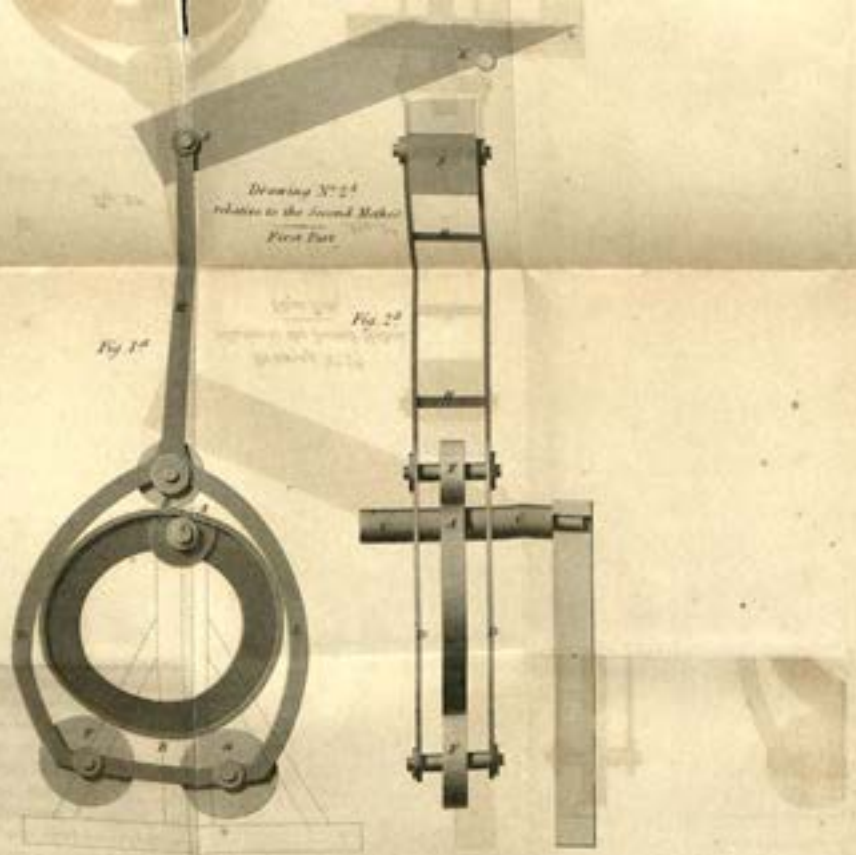
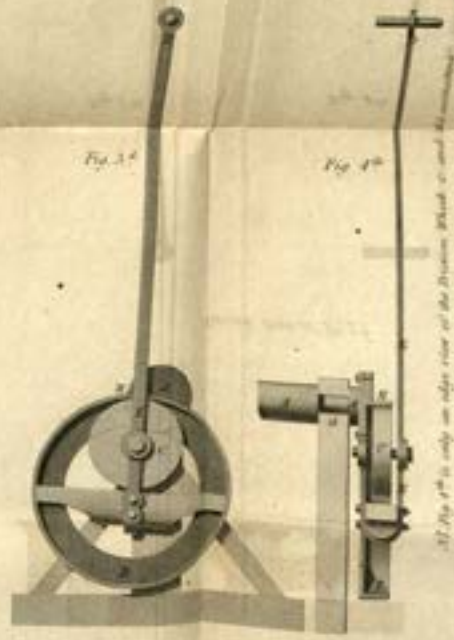


Fig 1st A view of a circular Excentric Wheel seen in the direction of the Shaft or Axis
A B The Excentric Wheel. C by Shaft or Axis. E F G Division Wheels. H I K A Frame of
Iron to which the division wheels are suspended to, and connected with J K one end
of the Working Beam of the Steam Engine ... Fig 2d an Edge view of the Excentric
Wheel. The same letters refer to the same parts as in Fig 1st

Second Part of N° 2d

Fig 3d

Fig 4th



3d Fig 4th is only an edge view of the Division Wheel e and the Excentric
Rod A B, but in a Section of the Excentric Wheel A B

Fig 3d and 4th Represent the Application of the second Method to the outward circumference of an
Excentric Wheel ... Fig 3d view of the Excentric Wheel or the direction of the Shaft.
A the end of the Axis or Shaft which is behind the wheel. A B The Excentric Wheel
C The Division wheel which is connected with the working Beam of the Steam Engine
by means of the Rod J D which is suspended to the working Beam by the end D
Fig 4th Edge of the Excentric wheel & the Shaft

Scale

wheel, fixed upon an axis or shaft in such manner that the said axis or shaft shall not pass through the centre of the said circular, oval or double spiral wheel, but shall be fixed nearer to one side of the circumference than to the other, which therefore I denominate an excentric wheel; and the said action of the steam engine and of the said friction wheel or wheels upon or against the circumference of the said excentric wheel, causes it to make one-half of a revolution, and its motion is continued through the other half revolution by the descent of a weight fixed to or acting upon the said excentric wheel or its shaft, or acting upon another excentric wheel, (fixed to the same shaft), by means of a friction wheel or wheels. This second method also admits of several varieties in its application, of which I have hereunto annexed a delineation of two of the best, shewing the action of the steam engine on the external and also on the internal circumference of excentric wheels, which drawings are delineated and set forth according to their true proportions, by a scale of one-fourth of an inch for each foot of their real size; but the said machines are also made larger or lesser, and the proportions of their parts varied, according to the uses for which they are required. The excentric wheel, whose external circumference is acted upon by the steam engine by means of friction wheels, is moved as follows—(see the drawing No. 2, figure 1st)*: the steam

* See Plate iv., figures 1st and 2nd.

engine pulls up the frame H D L with the friction wheels F, G, against the external circumference of the excentric wheel A B, which causes it to revolve on its axis towards D, until the point A of the excentric wheel comes to be in the middle between the points of contact of two friction wheels F, G, with the excentric wheel, and the point B has attained the summit of its motion; then the steam engine ceases to act, and the velocity acquired by the excentric wheel A B carries its point B beyond the summit, and the gravity of the unbalanced part of the excentric wheel, which is made equal to half the power of the steam engine, or greater or lesser as may be necessary, causes the excentric wheel to perform the other half revolution, by which motion it pulls down the frame H D L and the end J of the steam engine's working beam, and the point B having past its lowest place, the engine begins to act as before. The action of the steam engine on the internal circumference of an excentric wheel is described as follows: when the engine pulls up the frame D E, (see the annexed drawing, No. 2, figure 3rd),* with the friction wheel C, the latter is pressed against the internal circumference of the excentric wheel at H, by which means the wheel is turned round half a revolution, and the point B becomes the vertex; then the engine ceases to act, and the weight of the wheel descending causes it to continue to revolve in the same direction, and

* See Plate iv., figures 3rd and 4th.

completes the revolution, in like manner as has just been described.

My Third Method of producing the said rotative motion is by means of a rod or rods D B, (see the drawing, No. 3, fig. 1st),* one end (D) of which is attached or suspended to the end of the working beam of the steam engine, and the other end B to any point of a wheel A E B F, of a circular or any other form, which wheel is fixed at one end of a shaft or axis C; so that by the revolution of the said wheel and the said axis C, the said latter point of fixture or attachment B shall describe a circle round the centre of the said axis, the diameter of which circle shall be equal to the extent of the stroke of the point of the engine's working beam, to which the end D is attached; and the said wheel A E B F is made so much heavier on one side E B F of the centre than upon the other side A, that the said unbalanced weight E B F shall have an action in its descent equal to one-half of the power of the steam engine which works the machine, or more or less as required; or in place of putting the weight in the wheel A B F itself, it is put upon a lever or other wheel fixed to the said shaft C C in any other part, or is fixed in any other manner which may serve to make the wheel continue its motion during the return of the piston of the steam engine; and this machine is used as follows: when the point or pin B, which connects the rod D B with the wheel, is a little on either side of the

* See Plate v., figures 1st and 2nd.

lowest part of its revolution, the steam engine pulls the rod D B, and thereby obliges the wheel to make one half of a revolution, and the unbalanced weight E B F of the wheel, or such other weight as acts upon it during the return of the steam engine, makes the wheel complete its revolution, as has been already recited in the other methods. This third method also admits of several varieties in the mode of execution, for the wheel is sometimes placed so as to turn vertically, (as in the drawing), and sometimes to turn horizontally, and also at other inclinations to the horizon, and the balancing weight is also placed in various situations: I have therefore delineated only one of the most simple and perfect of these methods in the drawing No. 3,* hereunto annexed, which is laid down by the same scale with the other drawings of the preceding methods, but the size of the machine must be greater or lesser, and the proportions of its parts varied, according to its use.

My Fourth Method of producing the aforesaid rotative motion consists in employing two steam engines to produce a rotative motion in one and the same axis or shaft by any of the aforesaid three preceding methods, or by that which is hereinafter described, and in applying these two steam engines in such manner that the second engine shall begin to act when the first engine has made the said shaft revolve upon its axis one third part of a revolution or thereabouts, and con-

* See Plate v.

Drawing N.º 3.

Relative to the Third Method.

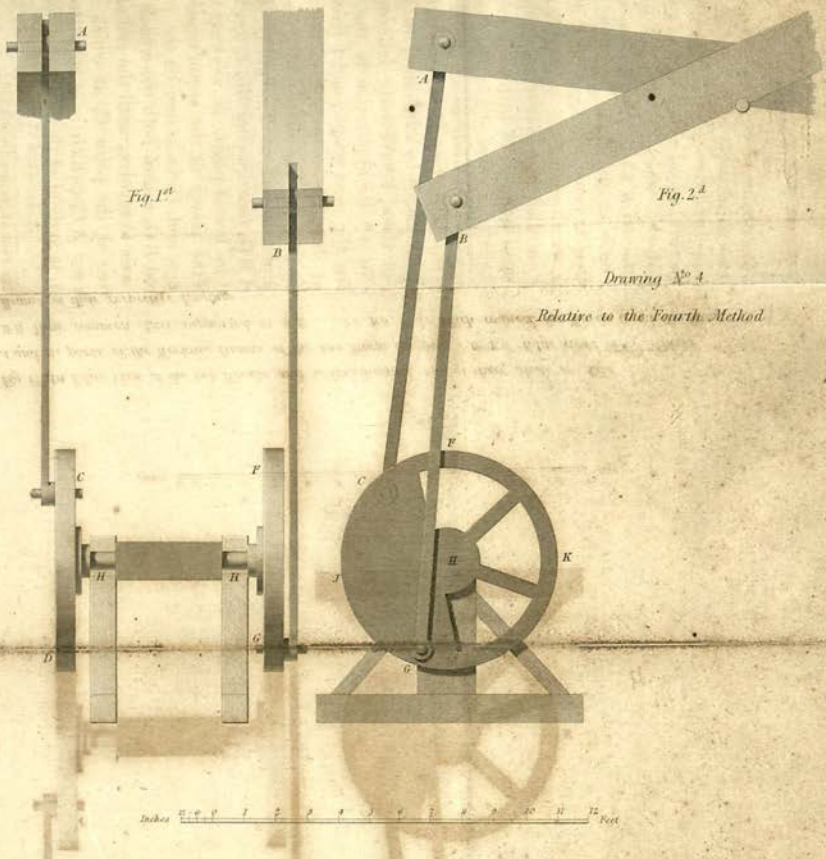
Fig. 1.st

Fig. 2.d

Fig. 1.st Front view of the Primary Rotative Wheel — A B The Wheel — C Its centre or axis E B F The heavy side of the Wheel — B The point of attachment of the Rod B D which connects the wheel with the working Beam of the Steam Engine — D The end of the Rod which is attached to the Working Beam

Fig. 2.d An Edge view of the Wheel and its Shaft. &c.

John Murray, Albemarle Street, London, 1854.



Drawing N° 4

Relative to the Fourth Method

Fig. 1st An Edge View of the two Wheels and a longitudinal one of their Shaft or Axis
A and B, parts of the Working Beams of the two Steam Engines C D, F G, Edge views of the Wheels
H H Their common Axis supported at H H ___ A C, B G, Rods which connect the Wheels to the Working Beams of their respective Engines
Fig. 2d Front view of the Wheel F G (the other wheel C D being hid by F G in this view) ___ A B parts of the Working Beams of the two Steam Engines ___ A C the connecting Rod of the further Wheel C D ___ B G the connecting Rod of the nearest Wheel (J F G)
H the Centre of the Wheels and of their Shaft or Axis ___ C J G The heavy side of both Wheels

London, 1834.

sequently, by the action of both the engines, the shaft makes two third parts of a revolution, and its motion is continued through the remaining one third part of the revolution by the action of a weight properly placed, by which means the rotative motion is maintained in a more equal manner than can be done by a single steam engine. I also apply this method to move two separate or distinct shafts or axles, which are connected in their action by wheel-work, or otherwise, so that they both must revolve the same number of turns in the same time. As this fourth method must admit of many varieties in its application to any or all of the three preceding or the following methods, all which may be easily understood by explaining its application to one of them, I have only delineated in the drawing No. 4 * its application to the third method, as being the most simple, and I have laid down the said drawing according to the same scale with the others. The motion of this machine is explained as under. The pin G of the connecting rod B G, (see drawing No. 4, fig. 2nd), having passed its lowest point, the working beam B ascends by the power of the steam engine to which it belongs, and, by its action on the pin G through the rod B G, causes both the wheels and their common axis to revolve, until the end of the rod B G arrives at the point C, at which time the end of the rod A C, (which is attached to the further wheel), is arrived at the point K, (that is,

* See Plate vi., figures 1st and 2nd.

a point of the further wheel directly behind K in this view), and the centre of gravity of the weight, or heavy sides of the wheels G, J, C, has passed its vertex or highest part at F, and begins to descend towards K; the rod B G continues to act upon the wheels until it arrives at F, where it ceases to act, and the motion is continued only by the gravity of the heavy side of the wheels, or by any other properly disposed weight, until the point C of the further wheel has past its lowest place, and comes into the position directly behind G, when the steam engine belonging to the rod A C begins to act, and continues the motion until it arrives again at C, when the revolution is completed, and the rod B acts as before: the heavy sides of the wheels, or any other weight used to continue the motion, ought to be equal to one-half of the power of one of the engines, but may be greater or lesser, as suits.

My Fifth Method of producing the aforesaid rotative motion, (delineated in the drawing No. 5 hereunto annexed),* is performed by means of a toothed wheel E, (fig. 1st), fixed upon the end of the shaft or axis F which is to receive the rotative motion; which wheel E is acted upon and made to revolve by means of a second toothed wheel D of an equal, or greater, or lesser diameter, which is firmly fixed to or connected with a rod A B, (the other end of which is attached or hung to the working beam B C of the steam engine, or is other-

* See Plate vii., figures 1st and 2nd.

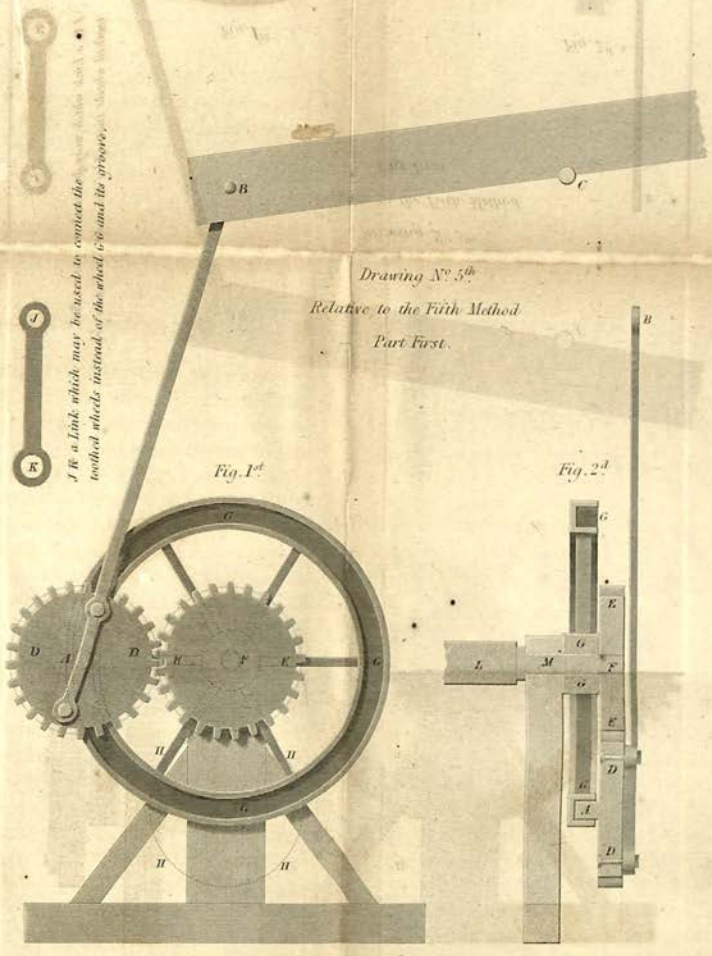


Fig.1st Front view of the Machine. B part of the working Beam of the Steam Engine. C Its Gudgeon or Axis. D D A toothed wheel fixt to the connecting Rod A B which without turning upon its own centre revolves round the other toothed Wheel E E which is fixed upon the Primary Rotative axis F, and which is made to turn round by the teeth of D D. A a Pin projecting from the Back side of D D, which being guided by the Groove G G keeps the toothed wheels always in contact.—— Fig. 2d Edge view of the Machine.

John Murray, Albemarle Street, London, 1854.

Fig. 3d

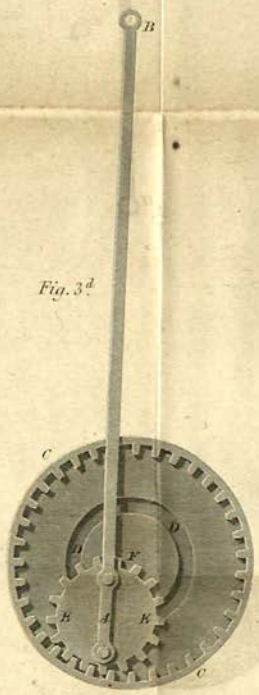


Fig. 4th

Fig 3d. Front view of the application of the Fifth method to a rotative wheel having teeth on its internal circumference. C C. The Rotative wheel which is made to turn round by the action of the wheel E E within it. E E a wheel fixt to the connecting Rod A B. The pin A keeps the two wheels always in contact by moving in the Groove D D. Fig 4th Section of the machine through its Axis.

J.W. Lowry fculp

John Murray, Albemarle Street London 1854.

wise connected with the piston of the said engine), in such manner that the said wheel D cannot turn round on its own axis or centre; and by means of a pin A, which is fixed to, or in the centre of the wheel D, and enters into a groove or circular channel in the large wheel G G, (or by any other proper means), the wheel D is confined so that it cannot recede from the wheel E, but can revolve or turn round the wheel E without turning on its own axis or centre, and the motion is performed as follows. The wheel D being nearly in the position of the pricked circle H H, and so that its centre shall be a little towards either side of the perpendicular line passing through the centre F; the steam engine, by means of the connecting rod B A, pulls the wheel D upwards, and, as its teeth are locked in the teeth of the wheel E, and it cannot turn on its own axis, it cannot rise upwards without causing the wheel E to turn round upon its axis F: when the wheel D is raised so high that its lower edge is come into contact with the upper edge of the wheel E, the engine has completed its stroke upwards, the piston of the engine is disposed to return, and the wheel E, continuing to turn round in virtue of the motion it had acquired, it carries the wheel D past the vertex or highest part, and the gravity of the wheel D, or of the connecting rod A B, or of any other weight connected with them, causes the wheel D to descend on the other side of the wheel E, and thereby continues the motion it had impressed upon it, whereby the wheel D completes its revolution round E; and when the two wheels

D and E have equal numbers of teeth, the wheel E makes two revolutions on its axis for each stroke of the engine; and in order that the said motion may be more regular, I fix to or upon the shaft or axis F M L, (fig. 2nd), or to or upon some other wheel or shaft to which it gives motion, a heavy wheel or flyer, to receive and continue the motion communicated to it by the primary movement. AND BE IT REMEMBERED, that in all cases where heavy wheels or swift motions are not otherwise necessary to the uses to which any of the four preceding methods herein described may be applied, a flyer or heavy rotative wheel should be applied to them to equalise their motion. In figures 3rd and 4th,* I have delineated the application of this method to a wheel C C, fixed upon the primary axis, and having teeth upon its inside circumference, which is acted upon by the wheel E in the manner which has just been recited; but as the wheel E has only half the number of teeth that the wheel C C has, the wheel C C will make only one revolution for every two strokes of the engine. The drawings of this fifth method are also delineated according to a scale of one-fourth of an inch for every foot of the real size of the machine. Figures 1st and 2nd are adapted to a stroke of six feet long, and figures 3rd and 4th to a stroke of three feet long, but I make the machines larger or lesser, and also make such variations in their structure as may serve to accommodate them to their use; as I alter the proportional

* See Plate vii., figures 3rd and 4th.

diameters of the two wheels, and I place the primary axis either horizontally, perpendicularly, or inclined, and I make the wheels of an elliptical, oval, or other form; and sometimes, in place of the wheel D, I use a straight row of teeth or pins fixed to the connecting rod A B, which take hold of the teeth of the said wheel E, and cause it to revolve; some point of the connecting rod being guided by a pin moving in a groove, so as to keep the teeth or pins always engaged in the teeth of the wheel E, and also to keep the teeth of the wheels always engaged in one another instead of the wheel G G and its groove. I use a strap of leather or a link of iron, or other proper material, (such as is drawn at J K), which embraces the axis M or F, and the pin A, and connects them together, and keeps them at their proper distance from each other; and I also make the two wheels E and D without any teeth, but with rough surfaces, so that D turns E by the friction of their circumference alone. BE IT REMEMBERED, that though I have described all these motions as derived or produced from the motion of the end of the working beam of the steam engine, they may also be derived from the vibrating motion of any other part of the steam or fire engine which is found convenient: the end of the working beam appears at present to be the best adapted for that purpose: any or all of these methods admit of the machines being moved with rotative motions in either direction, that is, either right-hand ways or left-hand ways about, according as the motion is commenced in either of these directions respectively.

In Witness whereof I have hereunto set my hand and seal, the thirteenth day of February, in the year of our Lord one thousand seven hundred and eighty-two.

James Watt.

Signed, sealed, and delivered, being first duly stamped, by the within named James Watt, in the presence of

N. Bennett, Clerk to Mr. Davis of Penryn.
Benj. Collett, Servant to Mr. Davis.

Inrolled in His Majesty's High Court of Chancery, the twenty-third day of February, in the year of our Lord 1782, being first duly stamped according to the tenor of the Statutes made in the sixth year of the reign of their late Majesties King William and Queen Mary, and in the seventeenth year of the reign of His Majesty King George the Third.

John Mitford.

1. P. Y.

SPECIFICATION OF PATENT, MARCH 12TH, 1782, FOR CERTAIN NEW IMPROVEMENTS UPON STEAM OR FIRE ENGINES FOR RAISING WATER, AND OTHER MECHANICAL PURPOSES, AND CERTAIN NEW PIECES OF MECHANISM APPLICABLE TO THE SAME.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Birmingham, in the county of Warwick, Engineer, send greeting.

WHEREAS His Most Excellent Majesty King George the Third, by His Letters Patent, under the Great Seal of Great Britain, bearing date at

* In this specification are comprehended the following "new improvements:"—

1. The use of steam on the expansive principle; together with various methods or contrivances, (six in number, some of them comprising various modifications), for equalising the expansive power.

2. The double-acting engine; in which steam is admitted to press the piston upwards as well as downwards; the piston being also aided in its ascent as well as in its descent by a vacuum produced by condensation on the other side.

3. The double-engine; consisting of two engines, primary and secondary, of which the steam-vessels and condensers communicate by pipes and valves, so that they can be worked either independently or in concert; and make their strokes either alternately or both together, as may be required.

4. The employment of a toothed rack and sector, instead of chains, for guiding the piston-rod.

5. A rotative engine, or steam-wheel.

1. It appears from one of Mr. Watt's letters, (to Mr. Boulton, 19th November, 1781, No. [202.], vol. ii. p. 135, *supra*), that he had first thought of the expansive engine in 1767; and had also explained it to Mr. Smeaton, at Soho, some years previous to 1781. Its principle is a curious one, and appears at first paradoxical; for, in fact, by cutting

Westminster, the twelfth day of March, in the twenty-second year of His reign, did give and grant

off the supply of steam at a certain point before the steam-vessel or cylinder is full, the same effect is produced as if the steam-vessel had been entirely filled with steam: the expansion or elastic force which the steam exerts doing the same work that in the other case would have been done by a greater quantity of steam, and, therefore, a further expenditure of fuel. The proportion of steam specified by Mr. Watt as being most convenient for admission, in common use, was one-fourth of the contents of the steam-vessel; producing an effect equal to more than one-half the effect that would have been produced had steam been admitted to enter freely into the cylinder during the whole length of the stroke of the piston. But he adds that any other proportion would produce similar [proportional] effects, and that in practice he did vary the proportions accordingly.

But the powers thus exerted by the steam being unequal at different periods of the stroke, while the resistance to be overcome, or work to be done, by the engine, was supposed to be equal throughout the whole length of each stroke, it was necessary to equalise the power of the engine; for doing which six different methods are specified. And, as of two of them, (viz. the first and third), there are two varieties, and of another, (viz. the fifth), there are four varieties, we have here no fewer than eleven varieties of such equalising machinery described, for particulars of all of which reference must be made to the specification, and relative plates.

2. The double-acting engine, as appears from the letter to Mr. Boulton already referred to, where Mr. Watt calls it the "double "cylinder," was also imagined by him about 1767. A large drawing of it on parchment, now in our possession, made from a sketch by Mr. Watt, was laid before the Committee of the House of Commons when Mr. Watt was soliciting the Act of Parliament for the extension of the patent, in 1774–5. The reason of it not having been sooner secured by a patent, was the difficulty which its inventor "had encountered "in teaching others the construction and use of the single engine, and "in overcoming prejudices:"—and the patent of 1782 was even then taken out only in consequence of Mr. Watt "finding himself beset "with an host of plagiaries and pirates." In the same time, and with almost the same machinery, the engine on this new principle was enabled to do double the work of the single engine, independent of the additional saving resulting from the use of the expansive principles already explained, by which it could be used as a double-acting expansive engine; in which case the fourth, fifth, and sixth of the contrivances

unto me, the said JAMES WATT, His especial licence, full power, sole privilege and authority,

for equalising the powers of the steam are specified as being peculiarly applicable.

One of the earliest double-acting engines completed for sale was one of those for the Albion Mills, erected in 1786, at the south-east corner of Blackfriars Bridge. "The mention of the Albion Mills," says Mr. Watt, "induces me to say a few words respecting an establishment so "unjustly calumniated in its day, and the premature destruction of "which by fire, in 1791, was not improbably imputed to design. So "far from being as misrepresented, a monopoly injurious to the public, "it was the means of considerably reducing the price of flour while it "continued at work.

"It consisted of two engines, each of fifty horses power, and twenty "pairs of millstones, of which twelve or more pairs, with the requisite "machinery for dressing the flour and for other purposes, were gene-"rally kept at work. In place of wooden wheels, always subject to "frequent derangement, wheels of cast-iron, with the teeth truly "formed and finished, and properly proportioned to the work, were "here employed; and other machinery, which used to be made of "wood, was made of cast-iron, in improved forms; and I believe the "work executed here may be said to [have] form[ed] the commence-"ment of that system of mill-work which has proved so useful to this "country. In the construction of that mill-work and machinery, "Boulton and Watt derived most valuable assistance from that able "mechanician and engineer, Mr. John Rennie, then just entering into "business, who assisted in planning them, and under whose direction "they were executed. The engines and mill-work were contained in "a commodious and elegant building, designed and executed under the "direction of the late Mr. Samuel Wyatt, architect." (Notes on Robison, p. 137.) We may add, that Mr. Peter Ewart was then Rennie's apprentice, was sent for from Scotland expressly to assist in the erection of those mills, and was employed for four years upon them as a millwright; when his great mechanical talents and industry sufficiently recommended him to his future employers and patrons, Messrs. Boulton and Watt. (See the "Address of the President," James Walker, Esq., "of the Institution of Civil Engineers, to the "Annual General Meeting, January 17, 1843.")

We have here spoken of the "double-acting" engine, (a name sometimes applied to it on its first introduction), to distinguish it from the next of the new improvements included in the specification of 1782, viz.:—

3. The

that I, the said JAMES WATT, my executors, administrators and assigns, should, and lawfully might, during the term of years therein expressed, make, use, exercise, and vend, within that part of his Majesty's Kingdom of Great Britain called England, his Dominion of Wales, and Town of Berwick upon Tweed, my invention of "CERTAIN "NEW IMPROVEMENTS UPON STEAM OR FIRE ENGINES FOR RAISING WATER, AND OTHER MECHANICAL PURPOSES, AND CERTAIN NEW PIECES "OF MECHANISM APPLICABLE TO THE SAME;" in which said recited Letters Patent is contained a Proviso obliging me, the said JAMES WATT, by an instrument in writing under my hand and seal, to cause a particular description of the nature of my said invention, and in what manner the same is to be performed, to be inrolled in his Majesty's High Court of Chancery within four calendar months after the date of the said Letters Patent, as in and

3. The double, or *compound* engine, the nature and advantage of which are thus shortly described by Mr. Watt:—"A new compound engine, "or method of connecting together the cylinders and condensers of two "or more distinct engines, so as to make the steam which has been "employed to press on the piston of the first, act expansively upon "the piston of the second, &c., and thus derive an additional power "to act either alternately or conjointly with that of the first cylinder." —(Notes on Robison, p. 150.)

4. Toothed rack and sector, instead of chains, for guiding the piston-rod. In consequence of Mr. Watt's beautiful invention of the parallel motion, made at no distant date from that of this specification, the rack and sector may be looked on as having been only a temporary expedient to avoid the inconveniences which had been found to result from the old system of chains connecting the piston-rod to the beam.

5. Rotative engine, or steam-wheel. For the reason already mentioned when treating of the patent of 1781, it seems unnecessary to enlarge on this article, which is fully described in the specification.

by the said Letters Patent, relation being thereunto had, may more at large appear.

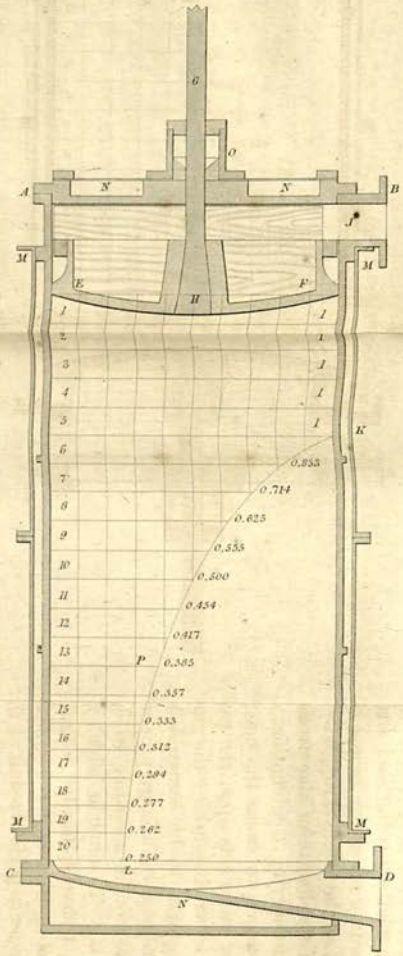
NOW KNOW YE, That in compliance with the said Proviso, I the said JAMES WATT do hereby declare that the nature of my said invention and the manner in which the same is to be performed, is described and ascertained in manner and form following, (that is to say): my said new improvements on steam or fire engines, and my said new pieces of mechanism applicable thereto, are described as followeth. But to prevent misunderstandings and circumlocutions or tautology, I shall first explain the meaning of certain terms which are used in this Specification. FIRST, the cylinder or steam vessel is that vessel wherein the powers of steam or air are employed to work the engine, of whatever form it may be made, though it is most commonly made cylindrical. SECOND, the piston is a moveable diaphragm, sliding up and down or to and fro in the cylinder, and fitted to it exactly, on which piston the powers of steam or air are immediately exerted. THIRD, the condensers are certain vessels of my invention, in which the steam is condensed, either by immediate mixture with water sufficiently cold or by contact with other cold bodies, which condensers are situated either in that part of the cylinder itself which the steam never enters, except to be condensed or reduced to water, or they communicate with the cylinder by means of pipes, which are opened or shut at proper times, or those pipes called eduction pipes, which lead to the air pumps or other contrivance for

carrying off the condensed steam, air, and water of injection, are themselves used for that purpose. FOURTH, the air and hot water pumps are pumps or other contrivances which serve to extract the air and heated water from the cylinders and condensers. FIFTH, the working beam is a double-ended lever, a wheel or wheels, or other machinery establishing the means of communicating the power from the piston to the pump work, or other machinery to be wrought by the engine.

MY FIRST NEW IMPROVEMENT in steam or fire engines consists in admitting steam into the cylinders or steam vessels of the engine only during some certain part or portion of the descent or ascent of the piston of the said cylinder, and using the elastic forces, wherewith the said steam expands itself in proceeding to occupy larger spaces, as the acting powers on the piston through the other parts or portions of the length of the stroke of the said piston; and in applying combinations of levers, or other contrivances, to cause the unequal powers wherewith the steam acts upon the piston, to produce uniform effects in working the pumps or other machinery required to be wrought by the said engine: whereby certain large proportions of the steam hitherto found necessary to do the same work are saved. To explain which principle or improvement, I have delineated a section of a hollow cylinder at figure 1st* in the annexed drawing. The said cylinder is perfectly shut at the lower end

* See Plate viii.

Fig. 1st



A B C D The Cylinder.

A B The cover of the Cylinder.

C D The bottom of the Cylinder.

E F The Piston.

G H The Piston Rod.

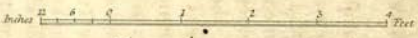
J The opening to admit Steam from the Boiler.

D The opening to let off the Steam into the Condenser.

M M A Case containing Steam and surrounding the Cylinder.

N N Cases containing Steam above and below the Cylinder.

K L A Curve the ordinates of which represent the powers of the Steam when the Piston is at their respective places.



John Murray, Albemarle Street, London, 1834.

by its bottom C D, and also at the upper end by its cover A B; the solid piston E F is accurately fitted to the said cylinder, so that it may slide easily up and down, yet suffer no steam to pass by it: the said piston is suspended by a rod or rods G H, which is capable of sliding through a hole in the cover A B of the cylinder, and its circumference is made air and steam-tight by a collar of oakum, or other proper materials, well greased, and contained in the box O; and near the top of the cylinder there is an opening J to admit steam from a boiler. The whole cylinder, or as much of it as possible, is inclosed in a case M M containing steam, or otherwise is maintained of the same heat with boiling water, or of the steam from the boiler. These things being thus situated, and the piston placed as near as may be to the top of the cylinder, let the space of the cylinder under the piston be supposed to be exhausted or emptied of air, steam, and other fluids; and let there be a free passage above the piston for the entry of steam from the boiler, and suppose that steam to be of the same density or elastic force as the atmosphere, or able to support a column of mercury of thirty inches high in the barometer. Then I say that the pressure or elastic power of the said steam on every square inch of the area or upper side of the piston, will be nearly fourteen pounds avoirdupois weight, and that if the said power were employed to act upon the piston through the whole length of its stroke, and to work a pump or pumps, either immediately by the piston rod, prolonged, or through the medium of a working

beam or great lever, as is usual in steam engines, it would raise through the whole length of its stroke a column or columns of water, whose weight should be equal to ten pounds for each square inch of the area of the piston, besides overcoming all the frictions and *vis inertiæ* of the water and the parts of the machine or engine. But supposing the whole distance from the under side of the piston to the bottom of the cylinder to be eight feet, and the passage which admitted the steam from the boiler to be perfectly shut when the piston has descended to the point K two feet, or one-fourth of the length of the stroke or motion of the said piston, I say that when the piston had descended four feet, or one-half of the length of the stroke, the elastic power of the steam would then be equal to seven pounds on each square inch of the area of the piston, or one-half of the original power; and that when the piston had arrived at the point P, the power of the steam would be one-third of the original power, or four pounds and two-thirds of a pound on each square inch of the piston's area; and that when the piston had arrived at the bottom or end of its stroke, that the elastic power of the steam would be one-fourth of its original power, or three pounds and one-half pound on each square inch of the said area. And I further say, that the elastic power of the steam at the other divisions marked in the lengths of the said cylinder, are represented by the lengths of the horizontal lines or ordinates of the curve K L, also marked or delineated in the said cylinder, and are expressed in decimal fractions of

the whole original power by the numbers written opposite to the said ordinates or horizontal lines. And I also say, that the sum of all these powers is greater than fifty-seven hundred parts of the original power multiplied by the length of the cylinder; whereby it appears that only one-fourth of the steam necessary to fill the whole cylinder is employed, and that the effect produced is equal to more than one-half of the effect which would have been produced by one whole cylinder full of steam, if it had been admitted to enter freely above the piston during the whole length of its descent; consequently that the said *New* or *Expansive Engine* is capable of easily raising columns of water whose weights are equal to five pounds on every square inch of the area of its piston, and that with one-fourth of the contents of the cylinder of steam. AND BE IT REMEMBERED, though, for example's sake, I have mentioned the admission of one-fourth of the cylinder's full of steam, (as being the most convenient), that any other proportion of the fill of a cylinder, or any other dimensions of the cylinder, will produce similar effects, and that in practice I actually do vary these proportions as the case requires. And also, in some cases, I admit the required quantity of steam to enter below the piston, and I pull the piston upwards by some external power against the elastic force of the steam from the boiler, which then always freely communicates with the upper part of the cylinder, and which produces similar effects to those described. But the powers which the steam exerts being

unequal, and the weight of the water to be raised, or other work to be done by the engines, being supposed to resist equally throughout the whole length of the stroke, it is necessary to render the whole acting powers equal by other means.

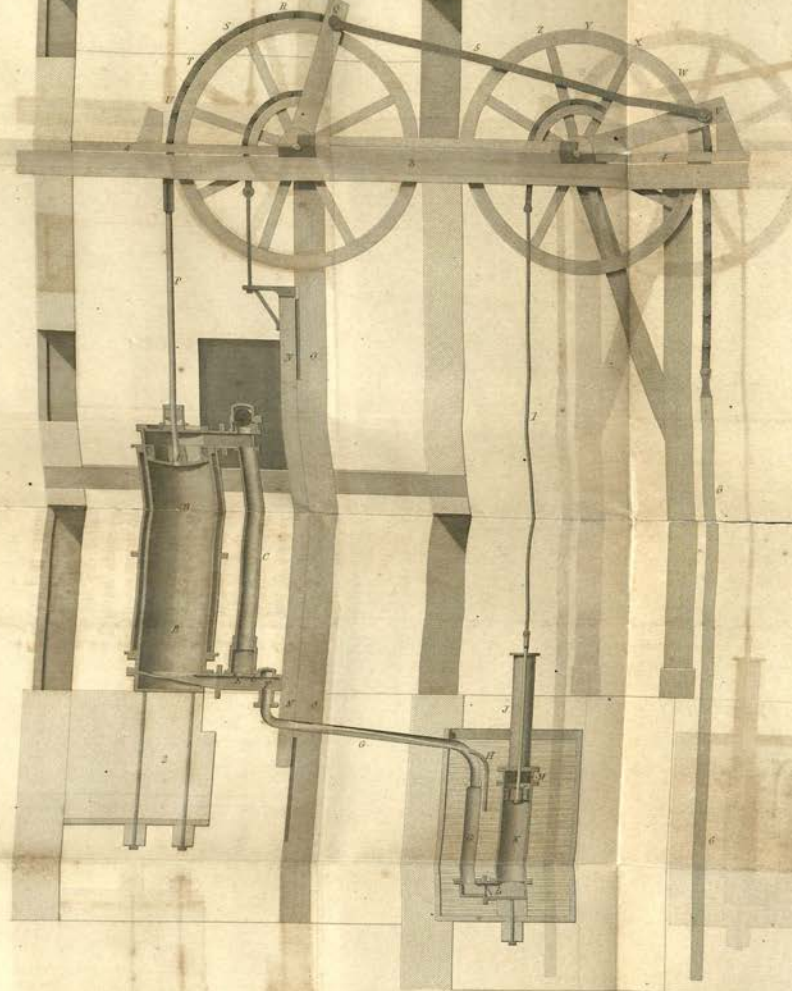
I PERFORM THIS, FIRST, by means of two wheels or sectors of circles, one of which is attached to the pump rods, and the other to the piston rod of the engine, and which are connected together by means of rods or chains, or otherwise, so that the levers whereby they act upon one another decrease and increase respectively during the ascent or descent of the piston, in, or nearly in, the ratios required. This method, mechanism, or contrivance, is delineated in fig. 2nd,* and also its application to one of my new invented steam engines, the sole use and benefit of which was granted to me by an Act of Parliament passed in the fifteenth year of the reign of his present Majesty. The operation of the engine with this new mechanism added to it is described as follows: The piston A being at its highest place, and the part of the cylinder under it exhausted of steam and air, the regulating valve which admits the steam to enter below the piston being shut, and the valve F which allows steam or air to pass to the condenser G K being open, in order to maintain a good vacuum, the top regulating valve D is opened, and permits the steam from the boiler to enter and act upon the piston, which then begins to descend, and to pull round

* See Plate ix.

A STEAM ENGINE.

having a Cylinder 30 inches in diameter and capable of making Strokes 8 feet long, with the First Species of the New Machinery for Equalizing the Expansive Powers of Steam applied thereto.

Fig. 2d



J.W.Lowry fculp.

Explanation of Fig. 2d

A The Piston. B B. The Cylinder or Steam Vessel. C. The perpendicular Steam Pipe which conveys the Steam from the upper to the under end of the Steam Vessel. D. The place of the Top regulating Valve. E. The place of the middle Regulating Valve. F. The place of the Eduction regulating Valve. G G. The Eduction Pipe. H. The injection Pipe. J. The Hot water Pump. K. The Air Pump. L. A Valve at the Eduction Pipe Foot, to prevent the regress of the Water. M. The passage to the Hot water pump. N. The Plug tree by the motion of which the regulating Valves are opened and shut. O. One of the Posts which guide the Plug tree. P. The Piston Rod. Q R S T U. The Wheel to which the Piston Rod is suspended. V W X Y Z. The wheel to which the Pump Rods are hung. 1. The Condenser Pump Rods. 2. A heavy Platform to which the Cylinder is fastened. 3. The Spring Beams. 4 4. The Springs. 5. The Rod which connects the two wheels which form the working Beam. 6. The Pump Rod.

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Feet

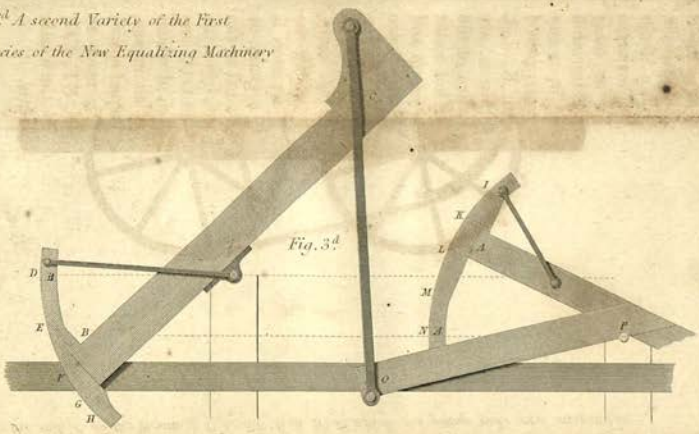
John Murray, Albemarle Street, London, 1834.

the wheel or sector of a circle to which it is hung: when the point Q of that wheel has moved to R, the piston has descended two feet, and the point V of the wheel to which the pump rods or other machinery wrought by the engine are suspended, being pulled by the rod, 5, connecting it with the other wheel Q R S T U, will have moved through the space V W, the regulating valve D is then shut, so that no more steam may be admitted from the boiler during that stroke, but the piston continues to descend by virtue of the expansion of the steam; and when the point Q is come to the points R S T U, the point V is come to the points W X Y Z, respectively describing spaces which are nearly proportional to the powers of the steam at the corresponding points of the descent of the piston: when the piston has made its stroke and is come to the bottom of the cylinder, the regulating valve F is shut, and the valve E is opened, by which means the steam passes from the part of the cylinder above the piston to the part below it, by the pipe C, and, so restoring the equilibrium, permits the piston to ascend to its first position. The regulating valve E is then to be shut, and the exhaustion regulating valve F is opened; the steam rushes into the eduction pipe G G, where it meets a jet of cold water, which enters through the injection pipe H, which is opened immediately before the regulating valve F. The contact of this cold water immediately reduces the steam to water, and produces a vacuum under the piston, and thereby enables the elastic force of the steam to act again upon it,

as has been described. Or, instead of injecting cold water into the condenser or eduction pipe itself, I bring the steam into contact with thin plates or pipes of metal, which have their external surface cooled by contact with water or other cold matter: the condensed steam, the injection water, and the air which entered with it, or any other air which has entered by other means, proceed by the eduction pipe to the air pump K, and, passing the valves of its bucket or piston, are retained and lifted up by it on the return of the stroke, and thereby are thrown into the hot water pump J, which by the next stroke raises up and delivers them into the atmosphere, from whence part is returned into the boiler to supply its consumption of water, and the remainder is conveyed away for any other purpose, or runs to waste. Another Variety of this method of equalizing the power is delineated in figure 3rd.* The piston is suspended to the arch A, by means of a chain, or otherwise, and the pump rod is suspended to the arch B. The primary or cylinder arch A, by means of the arm O P, and the rod or chain O C, acts upon the working beam B C, to the arch of which the pump rods are suspended, by which means, while the piston descends through the equal spaces J K, K L, L M, M N, the pump rod is made to ascend through the unequal spaces D E, E F, F G, G H, which are nearly proportioned to the elastic forces of the steam at the respective points.

* See Plate x., figure 3rd.

Fig. 3rd. A second Variety of the First Species of the New Equalizing Machinery



The Piston Rod is hung to the Arch A A, and by means of the Rod O C pulls down the end C of the Beam B C to the Arch B, of which the pump rods are suspended.

Fig. 4th.

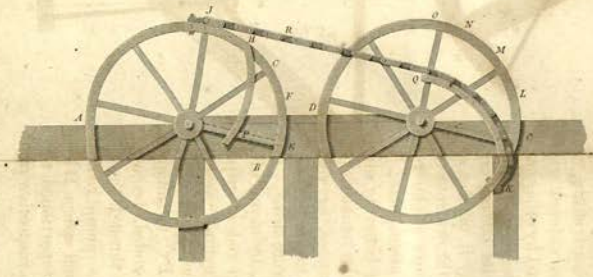


Fig 4th The Second Species of the New Machinery for Equalizing the Expansive Powers of Steam. The Piston of the Steam Vessel is hung by chains or otherwise to the side A of the Wheel A B, and by means of the Chains J R K and the Spiral Wheels J P & Q K pulls round the Wheel D C, to which the pump rods are suspended from the Arch O C.

Inches 0 1 2 3 4 5 15 25 30 feet

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John Murray, Albemarle Street London, 1854.

Fig. 5th.

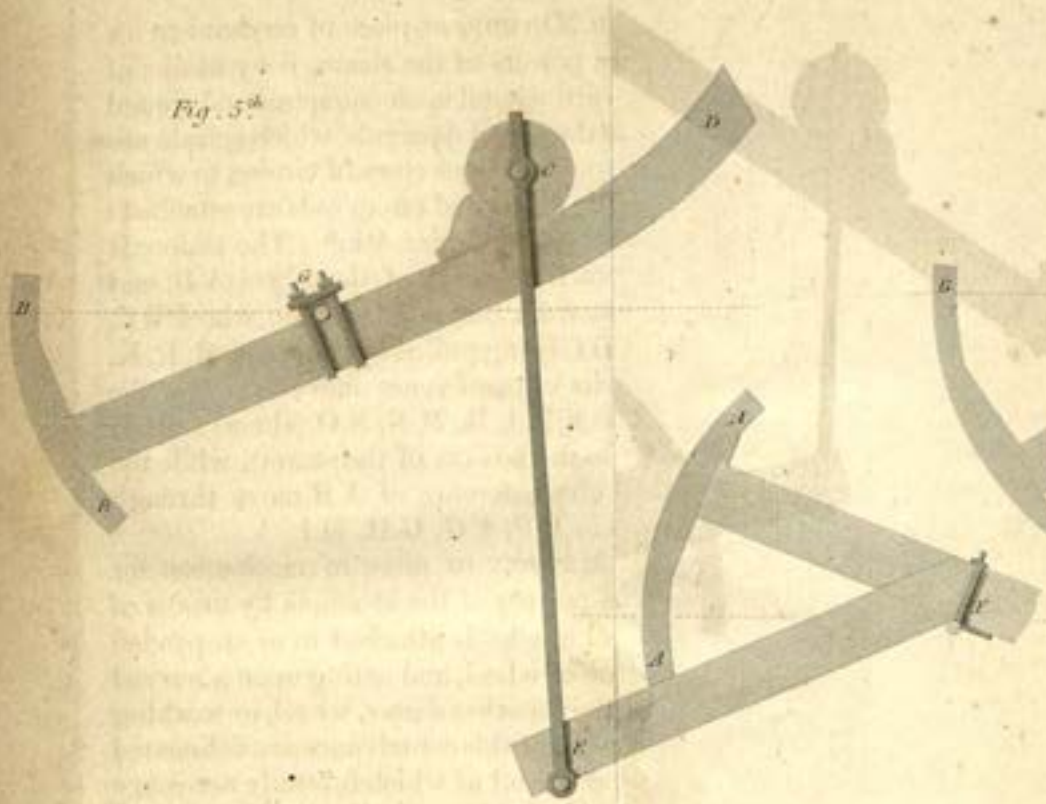
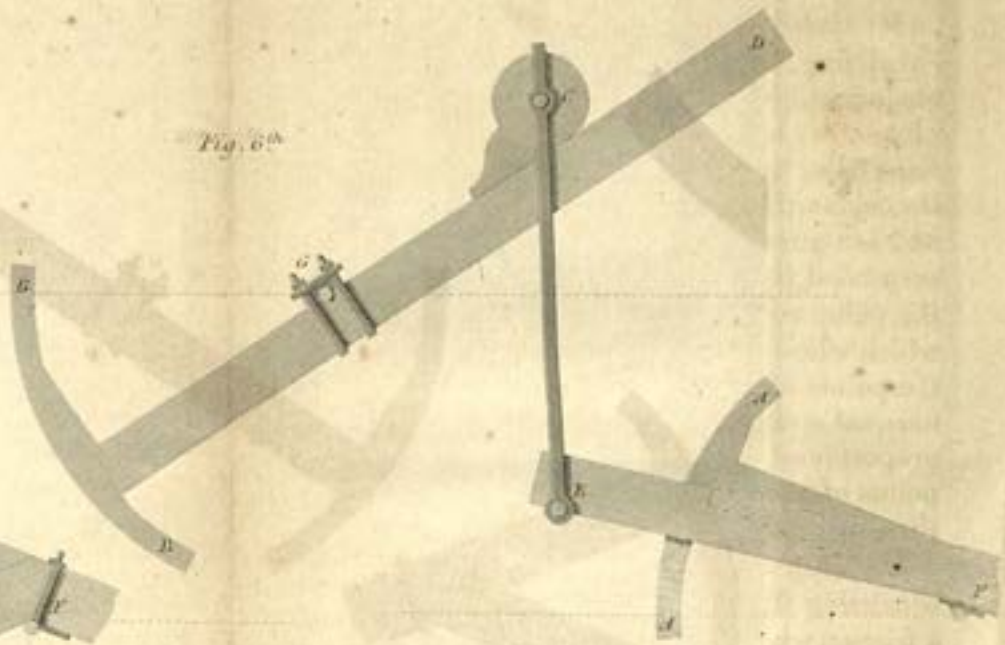
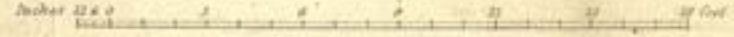


Fig. 6th.





Figs. 5th & 6th. Two varieties of the Third Species of the New Machinery for equalizing the Expansive Powers of Steam.

N.B. The arms E F and the connecting rods E C are supposed to be double in each Machine, that the Piston chains or racks may go up between them.

The Piston Rods of the Engines are suspended from the Arches A A and by means of the Connecting Rods E C pull down the Friction Wheels C C and the ends of the Beams B D on which they rest; and by the motion of the Friction Wheels on the Beams, the Levers are lengthened (nearly) as the powers of the Steam diminish.

John Murray, Albemarle Street London, 1834.

My Second Method, or piece of mechanism for equalizing the powers of the steam, is by means of chains, which are wound upon one spiral and wound off another as the piston descends, which spirals are fixed upon two wheels or sectors of circles, to which the chains of the piston and pump rods are attached: and is represented in figure 4th.* The piston is suspended from the side A of the wheel A B, and the pump rods from the side C of the wheel D C, which wheel D C being pulled by the chains J, R, K, the points of its circumference move through the unequal spaces K L, L M, M N, N O (almost exactly proportioned to the powers of the steam), while the points of the circumference of A B move through the equal spaces E F, F G, G H, H I.

My Third Method, or piece of mechanism for equalizing the powers of the steam, is by means of a friction wheel or wheels attached to or suspended from one sector or wheel, and acting upon a curved or straight part of another sector, wheel, or working beam. Two modes of this contrivance are delineated in figures 5th and 6th,† of which it is only necessary to observe that the pistons of the engines are suspended to the arches A A, and the pump rods to the arches of the working beams B B, and that these contrivances afford the means of equalizing the powers of the steam very exactly.

My Fourth Method, or piece of mechanism for equalizing the power of the steam, is by causing the centre of suspension of the working beam, or

* See Plate x., figure 4th.

† See Plate xi.

great lever, to change its place during the time of the stroke, whereby the end of the lever to which the piston is suspended becomes longer, and the end to which the pump rods are suspended becomes shorter, as the piston descends in the cylinder. An easy method of doing this is represented in figure 7th :* A B represents the working beam; B, the end to which the piston is suspended; A, the end to which the pump rods are suspended; C D, a hollow curve of wood or metal fixed to the lower side of the working beam; E, the end of a friction roller, which rolls between the curve C D and the plane or support F G. This friction roller is divided into three parts, as may be seen in its horizontal view K L M: the two end parts K M, which roll upon the supports F G, are fixed firmly upon an axis; the middle part L, which rolls under the curve C D, can turn round on its axis; therefore, when by the action of the piston on the working beam the end B is pulled downwards, the roller proceeds towards C to the part of the curve which is then the highest, and thereby lengthens the lever by which the piston acts on the pumps, and shortens that by which the pumps resist the cylinder, and that in any ratios which may be required, according to the form of the curve.

My Fifth Method, piece of mechanism, or contrivance for equalizing the power of the steam, consists in placing upon, suspending from, or fixing to the working beam of the steam engine, or some

* See Plate xii., figure 7th.

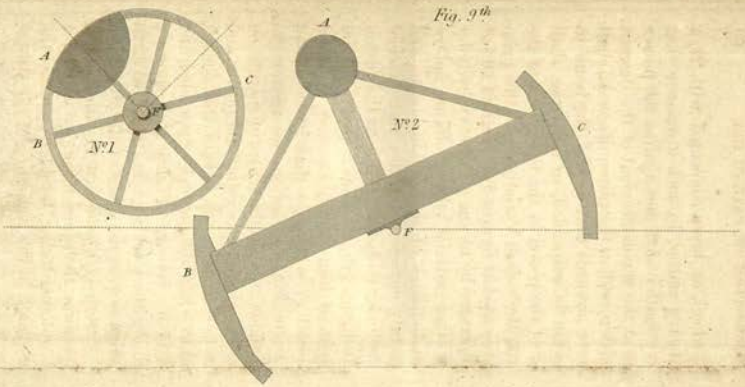


Fig. 9th Nos 1 & 2 The second Variety of the Fifth Species of the New Equalizing Machinery in Two Examples. A A The heavy Bodies placed or raised above the Centres of motion of the Wheel B C № 1 and of the working Beam B C № 2 F F The Centres of motion.

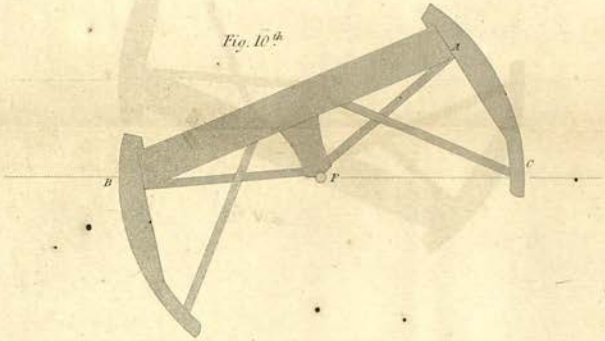


Fig 10th The Third Variety of the Fifth Species of the New Equalizing Machinery. № The Working Beam which is placed so high above its Centre of motion F that its own gravity acts the part of the Weight A in Fig. 9th

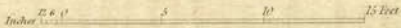


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Fig. 7th.

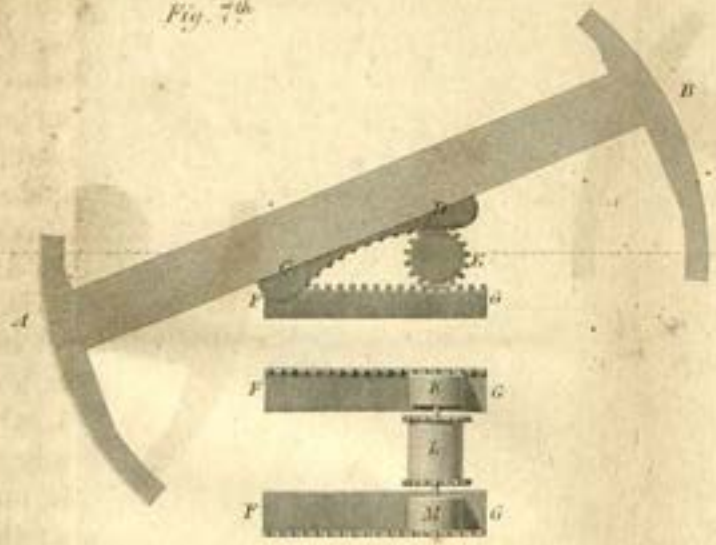


Fig. 8th.

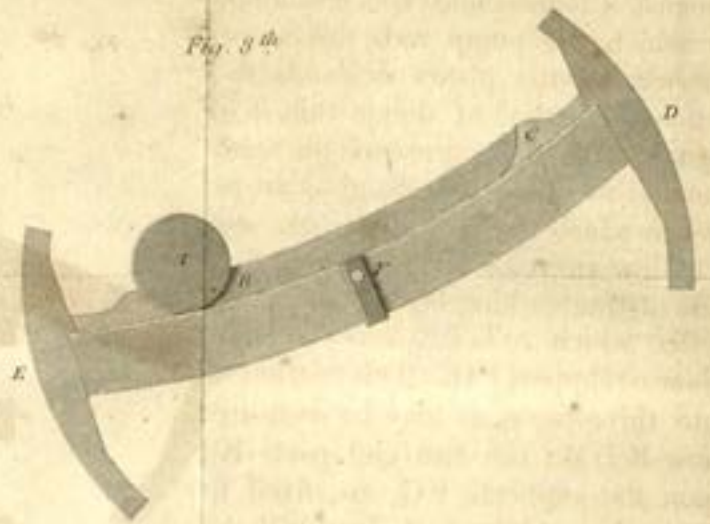
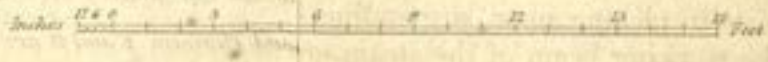


Fig. 7th. The Fourth Species of the New Equalizing Machinery. A B The Working Beam. C D a hollow Curve which rests upon the Roller E, and is furnished with teeth to keep it from sliding. F G a Flat Platform on which the end Rollers rest. K L M is a Horizontal View of the Rollers and Platform. K and M are fast on y^e axis, and L can turn round on it.

Fig. 8th. The First Variety of the Fifth Species of the New Equalizing Machinery. E D The Working Beam. A a weight which rolls in a hollow Curve B C. F The axis or Gudgeon.



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John Murray, Albemarle Street, London, 1854.

other beam, wheel, or lever connected with it, a quantity of heavy matter, in such a manner that the said heavy matter shall act against the power of the piston at the commencement of the descent of the said piston, and, as the piston descends, shall gradually move towards that end of the beam to which the piston is suspended, or otherwise shall act in favour of the piston in the latter part of the stroke. Three Methods or Varieties upon this principle are represented at figures 8th, 9th, and 10th.* Figure 8th operates by means of a heavy cylinder A, of iron or other material, which rolls in a hollow curve B C on the back of the working beam, and will consequently change its place, and proceed towards the cylinder end of the beam, as the piston descends. In figure 9th, the same is performed by a heavy weight of iron or other matter, A, fixed above the beam or wheel, so that its centre of gravity at beginning the motion lies nearer the pump end of the beam than the centre of suspension of the beam, whereby it acts against the piston, and at last comes to be at the same side of that centre, with the end to which the piston is suspended, and thereby acts in its favour. Figure 10th shows a method of fixing the working beam itself, so as to perform in some degree the office of the weight in figure 9th. Figure 11th† shows a Fourth Method, whereby I perform the same thing, by causing a quantity of water or other liquid to oppose the ascent of the piston in the beginning of the stroke,

* See Plates xii. and xiii. † See Plate xiv.

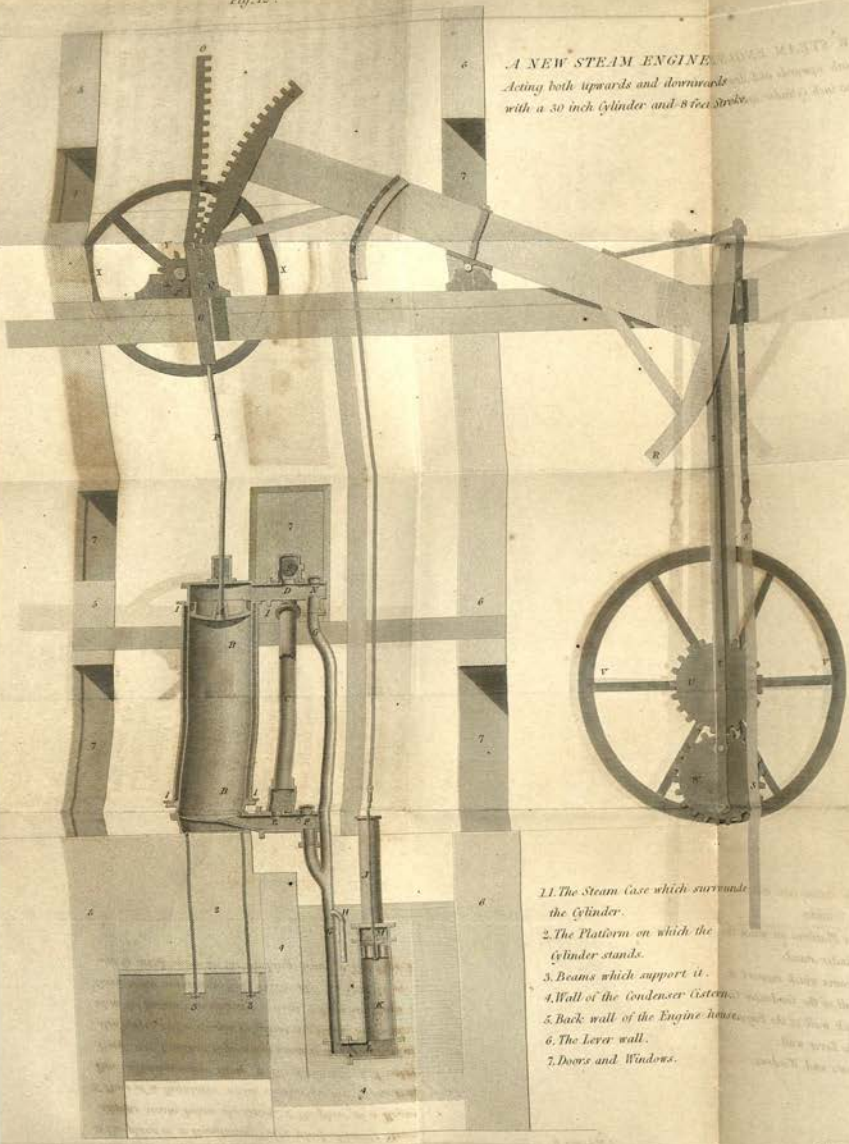
and to assist it in the latter part. A and B represent two cylinders or other formed vessels filled with water, or some other liquid, above their pistons C and D, the rods of which are fixed (or suspended) to the working beam of the engine, or such secondary or auxiliary beam as may be applied to this use, on the opposite sides of its axis. These cylinders are open at bottom and at top, and at the top part they are connected together by a lander or trough, close or open: when the piston descends, it raises the opposite end of the working beam and the piston of cylinder B, and thereby causes the water it contains to run over into A, the piston C of which, becoming loaded thereby in proportion as piston D rises, gradually comes to assist the piston of the steam vessel in the latter part of its motion. These cylinders, containing water, may be either placed below the working beam or above it, or may be suspended to a secondary working beam, constructed for that purpose, or necessary for some other use connected with the piston rod or pump rod, or other part, and placed so that the water cylinders may be out of the engine-house, in some place where it may be found to be more convenient.

My Sixth Method, piece of mechanism, or contrivance for equalizing the powers of the steam, consists in employing the surplus power of the steam upon the piston in the first parts of its motion, to give a proper rotative or vibratory velocity to a quantity of matter which, retaining that velocity, shall act along with the piston, and assist it in

Fig. 12th

A NEW STEAM ENGINE

Acting both upwards and downwards with a 30 inch Cylinder and 8 feet Stroke.



1.1. The Steam Case which surrounds the Cylinder.
2. The Platform on which the Cylinder stands.
3. Beams which support it.
4. Wall of the Condenser Cistern.
5. Back wall of the Engine house.
6. The Lever wall.
7. Doors and Windows.

J. W. Lowry fc.

Fig. 12th Represents the New Improved Engine, the Piston of which is pressed forcibly both Upwards and Downwards by the powers of Steam.
A. The Piston. B B. The Cylinder or Steam Vessel. C. A Pipe which brings Steam from the Boiler to the lower Regulator Box or Nozle.
D. The place of a Regulating Valve which Admitts Steam into the upper end of the Steam Vessel. E. The place of the Regulater which admitts Steam below the Piston. F. The place of a Regulater which letts Steam go out from below the Piston into the Condenser.
X. Place of a Regulator which discharges the Steam from above the Piston. G G. The Eduction or Condenser Pipe. H. The Injection Pipe. I. The hot water Pump. K. The Air Pump. L. A valve at the Eduction pipe foot. M. Passage from the Air Pump to the Hot water Pump. O O. A toothed Rack which connects the Piston Rod and the working Beam. P. The Piston Rod. Q Q. A Toothed Section or Arch which also serves for a Weight to assist the Piston in its descent. Q R. The working Beam. S S. The pump Rod which is made double when the Rotative Machinery is used. T. The Connecting Rod of the Rotative Machinery. U. The wheel fixed upon an axis. W. The wheel fixed to the connecting Rod. V V. The Fly. X X. The Pr of the reciprocating Rotative motion. Y. The Bunion by means of which it acts and is acted upon by the Working Beam. 9. The Pipe which brings Steam from the Boiler.

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Feet

Fig. II.th

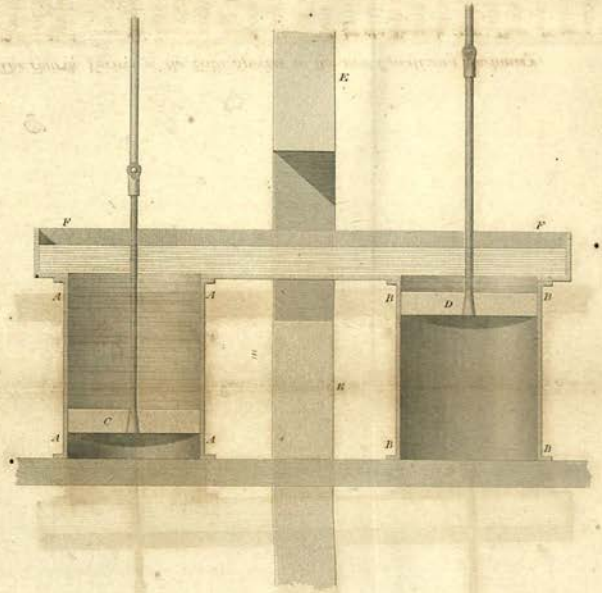
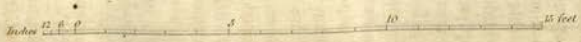


Fig. II.th The Fourth Variety of the Fifth Species of the new Equalizing Machinery.

A A. B B. Two cylinders containing water and connected by the Trough F F. Their Pistons C & D are supposed to be suspended from the opposite ends of a working Beam whose centre of motion, or Gudgeon, is supported upon the wall E E and which Beam is so connected with the Piston of the Engine, that when the Engine piston descends it raises the piston of the water Cylinder which is then lowest, & thereby causes the water which it contains to pass by the trough into the other water Cylinder and by its Gravity to assist the descent of the Piston of the Engine.

J.W. Lowry sculp.



John Murray, Albemarle Street, London, 1854.

raising the columns of water in the latter part of its motion, when the powers of the steam are defective: two methods by which I perform this are delineated in the drawing of the engine, figure 12th.* The heavy fly X X is put in motion by means of a pinion or smaller wheel Y fixed upon its axis, and the teeth of which pinion or smaller wheel are acted upon by the toothed sector Q Q, fixed upon the arch of the working beam; or the said fly is by other means connected with the motion of the said working beam. When the piston pulls down the end of the working beam, the toothed sector Q Q gives motion to the pinion, and thereby gives velocity to the fly; and when the descending or ascending velocity of the arch or sector of the working beam comes to be less than the velocity which the pinion and fly have acquired, then the velocity of the fly continuing, causes the pinion to act upon the sector in its turn, and assist the powers of the steam, until its velocity is spent, or the piston has reached the bottom of the cylinder; and the said fly operates in like manner during the ascent of the piston, but turns then in the contrary direction. In the Second Variety of this method, a fly, or heavy wheel, is put into a continued rotative motion by a crank, by any of the rotative motions for which I have obtained his Majesty's Royal Letters Patent, dated in the present year of his reign, or by any other means which shall or can produce a continued rotative motion. And the

* See Plate xv.

said rotative machinery is connected with or joined to either end of the working beam, to or with the piston rod itself, to or with the pump rods, or to or with any other moving part of the engine or pump rods which is found proper. In the drawing, figure 12th,* T, U, W, V, V represent the application of my Fifth Method of producing rotative motions from steam engines, as a method or contrivance for equalizing the power of the steam. The piston being at the top of the cylinder, and the working beam in the situation delineated, the engine begins its stroke, and, by means of the connecting rod T T, pulls upwards the toothed wheel W, which is fixed to the connecting rod in such manner that it cannot turn upon its own axis, and is confined by means of a link or chain reaching from its centre to the axis of the other toothed wheel U, or is otherwise contrived so that it cannot recede from it; therefore, when the action of the engine pulls the wheel W upwards, it revolves round the other wheel U, and causes it (U) to revolve upon its own axis; and the fly or heavy wheel V V being fixed upon the same axis, it is also put into motion, and because of the great power of the steam in the first parts of the stroke, the fly acquires a great velocity, whereby, through the medium of the two wheels and the connecting rod, it acts upon the working beam, and assists the action of the steam in the latter parts of the stroke: when the piston has completed its stroke down-

* See Plate xv.

wards, the lower edge of the wheel W has passed over the upper edge or highest part of the wheel U, and, the velocity of the fly continuing, the wheel U acts upon the wheel W, and assists the unbalanced weight of the pump rods in raising the piston to the top of the cylinder. BUT BE IT REMEMBERED, that I (the said JAMES WATT) do not mean that anything which I have herein set forth, touching or concerning this second variety of applying my Sixth Method or contrivance for equalizing the powers of the steam, shall be construed or thought to be intended to preclude any other person or persons from using or applying to the moving, turning, or working of mill-work or other machinery, where continued rotative motions are required, any contrivances or inventions for producing rotative motions from steam engines, provided that such rotative motions or machinery be not of my invention, and such engines be not applied principally or solely to the raising of water: the true intent and meaning of the aforesaid last article of this writing, being to specify the means by which I apply continued rotative motions, as some of my methods or contrivances to equalize the expansive powers of the steam, in engines which are used principally or wholly for the raising of water from mines, rivers, ponds, marshes, lakes, and other places.

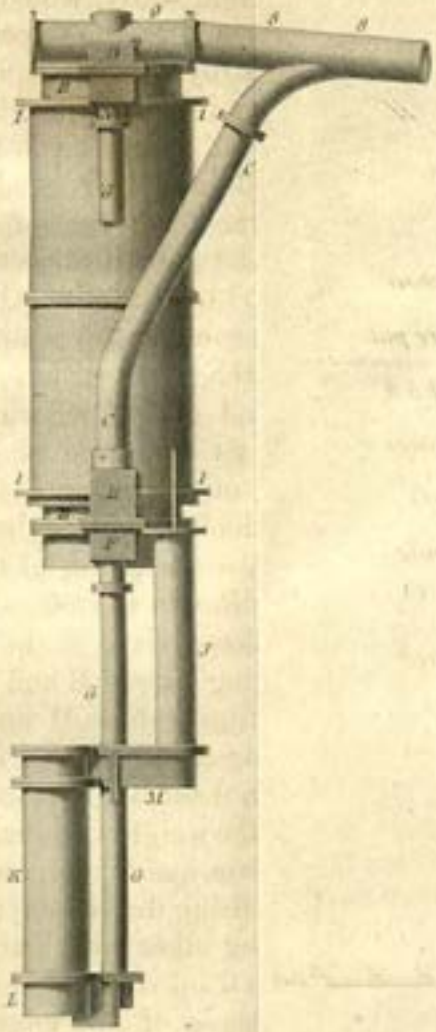
MY SECOND IMPROVEMENT upon steam or fire engines consists in employing the elastic power of the steam to force the piston upwards, and also to press it downwards alternately by making a

vacuum above or below the piston respectively, and at the same time employing the steam to act upon the piston in that end or portion of the cylinder which is not exhausted; so that an engine constructed in this manner can perform twice the quantity of work, or exert double the power in the same time, (with a cylinder of the same size), which has hitherto been done by any steam engine in which the active force of the steam is exerted upon the piston only in one direction, whether upwards or downwards. This improvement, as applied to one of the steam engines of my invention, is delineated in figure 12th.* The lower part of the cylinder B being exhausted of air, steam, and other fluids, the regulating valve F being open, and the regulating valves E and N being shut, the regulating valve D is opened, which admits the steam from the boiler to press upon the upper side of the piston, by the action of which steam the piston descends, pulls down the cylinder end of the working beam, and raises the end to which the pump rods are suspended. When the piston is arrived at the bottom of the cylinder, or end of its stroke, the valve F is shut, and the valve E is opened, which admits the steam under the piston, and at the same time the valve D is shut, which prevents the steam from coming from the boiler into that end of the cylinder, and the other valve N in the upper nozzle or regulator box is opened, which

* See Plate xv.

PLATE XVI.

Fig. 13th



A Front View of the Cylinder and Condenser of Fig. 12th in which the same letters are put upon the same respective parts and 8 8 represents part of the Pipe which brings Steam from the Boiler and 9 the Trofs Pipe fixed to the upper Nozzle or Regulator Box

N. B. The Eduction Pipe G is represented broken off to shew the other parts

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet

J. W. Lowry fc.

John Murray, Albemarle Street, London, 1854

permits the steam to rush from above the piston into the eduction pipe G G, where it meets the jet of injection water, which condenses it and produces a vacuum in the upper part of the cylinder, which, destroying the equilibrium, permits the steam under the piston to force it upwards. Then the piston rod being fast in the piston, and having the toothed rack O O fixed to its upper end by means of the teeth thereof, which are engaged in the teeth of the toothed sector which is fixed to or forms a part of the arch Q Q of the working beam, or by means of double chains or any other practicable method, the piston or its rod raises the cylinder end of the working beam, and also a heavy weight concealed or contained in the arch thereof, or otherwise fixed, attached, or suspended thereto; which weight ought to be equal, or nearly so, to the force or power of the steam when acting upon the piston in the ascending direction. When the piston has arrived at the summit of its motion, the regulating valves E and N are to be shut, and the regulating valves D and F opened, whereby the piston again commences its motion downwards, as has been described; and, during the descent of the piston, the weight Q Q, fixed or suspended to the working beam, assists the power of the steam on the piston, in raising the column of water in the pumps, or in working other machinery. In figure 13th* is delineated a front view of the cylinder, and a section of the condenser of this engine, wherein the pipes

* See Plate xvi.

which convey the steam from the boiler, and to the condenser, are properly distinguished and explained. This improvement permits the engine to be used either with the uniform exertion of the whole power of the steam on the piston, both in the descent and ascent; or, by making the weight of the columns of water in the pumps, or the resistance of other machinery which it may be required to work, equal to the full power of the steam upon the piston, when acting in one direction only, and the weight on the working beam equal to half that power, it may be used as a double expansive engine, and wrought in the manner I have herein set forth in the description of my First Improvement. And in such case the Fourth, Fifth, and Sixth contrivances herein described for equalizing the powers of steam, are peculiarly applicable to this mode of constructing the engine. Wherefore I have delineated the two varieties which I have described of the Sixth method as applied to this engine. AND BE IT REMEMBERED, that either or both of them may be used at the same time, though only one is strictly necessary, and that any other two or more of the aforesaid Six contrivances, or of the varieties thereof, may be applied to one engine at the same time; that is to say, such of them whose nature admits of such combination.

MY THIRD IMPROVEMENT on steam or fire engines consists in connecting together, by pipes or other proper channels of communication, the steam vessels and condensers of two or more

Fig. 11th

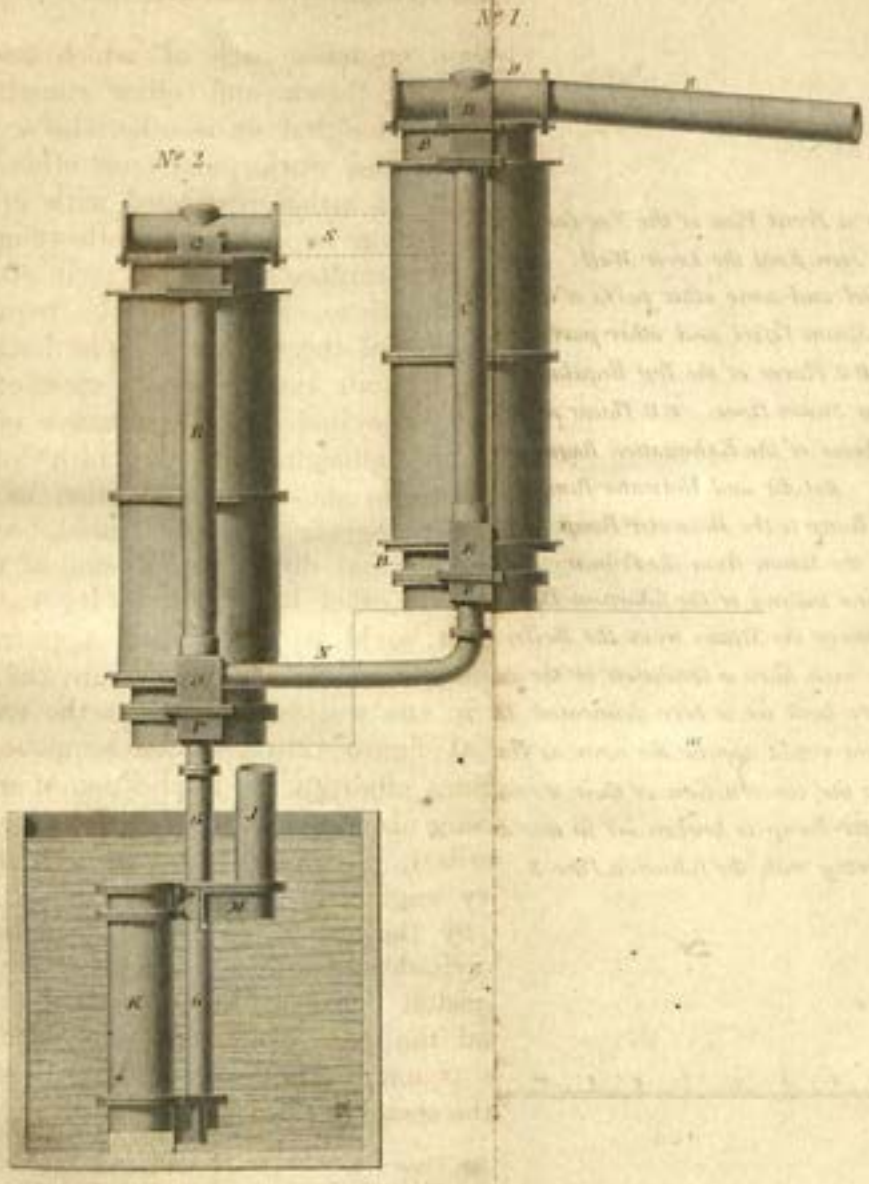


Fig. 11th Represents a Front View of the New Compound or Double Engine as seen from the Lever Wall.

N°1 The Steam Vessel and some other parts of the Primary Engine. N°2 The Steam Vessel and other parts of the Secondary Engine. D.Q. Places of the Top Regulating Valves. C.R. The Perpendicular Steam Pipes. E.O. Places of the Middle Regulators. F.P. Places of the Exhaustion Regulators. N.G. Eduction Pipes. K.I. Air and Hotwater Pumps. M. Passage from the Air Pump to the Hotwater Pump. S. A Pipe for communicating the Steam from the Primary Engine to the Secondary Engine instead of the Eduction Pipe N. 8.9. Pipes which convey the Steam from the Boiler. N.B. These Engines may each have a Condenser or the same Condenser may serve both as is here delineated. The side View of these Engines would appear the same as Fig. 2d or Fig. 12th according to the construction of their working Beams. The Hotwater Pump is broken off in this drawing to avoid its interfering with the Eduction Pipe N.

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 feet

J.W. Lowry fculp.

John Murray, Albemarle Street, London, 1854.

distinct steam engines; each of which has its separate working beam and other constituent parts of a steam engine, or is otherwise so constructed that it can work pumps or other machinery which are either connected with or are independent of those wrought by the other engine; and which two engines can take their strokes alternately, or both together, as may be required. The construction of the said machine is described as followeth, and an external front view of the steam vessels or cylinders and condenser of the two engines is delineated at figure 14th* of the drawings hereunto annexed: the section or side view of the two engines is not delineated, because when viewed in that direction only one of them can be seen, the other being hid by it; and the engine which could be seen would appear the same as the engine delineated in figure 2nd,† or, in respect to the working beams, as the engine delineated at figure 12th;‡—these compound or double engines admitting the application of any of the equalizing machinery which has been hereinbefore described. In figure 14th,§ the cylinder of the primary engine, No. 1, receives steam from the boiler by the steam pipe 8, 9, which steam enters the cylinder by a regulating valve situated at D, its piston being at the upper end of its stroke; and the part of the cylinder which is below the piston being exhausted, the elastic power of the steam presses down the piston until

* See Plate xvii.
† See Plate ix.
‡ See Plate xv.
§ See Plate xvii.

it arrives at the bottom or termination of its stroke: the regulating valve D is then shut, and the middle regulating valve at E is opened, which admits the steam to enter under the piston, whereby the engine is enabled to raise up the piston to the top of its stroke, where it was at the beginning: the middle regulating valve E is then shut, and the regulating valves F and P are opened: the valve F permits the steam to pass through the eduction pipe N into the perpendicular steam pipe R of the secondary engine, and to press upon its piston, under which piston there is a vacuum. The steam which is or was contained under the piston of the primary engine, No. 1, being of the same density with the atmosphere, or nearly so, will, while the piston of the secondary engine, No. 2, remains stationary, act upon it with the full power belonging to its density or elasticity, and will thereby cause it to commence its motion downwards; but as the piston of No. 2 moves downwards, the density and elastic force of the steam will diminish in proportion as the spaces which it occupies are increased; so that, (in case the cylinders of the two engines are of an equal capacity), when the piston of No. 2 has arrived at the bottom or lower end of its stroke, the density and elastic force of the steam will be only one-half of what they were while the piston remained at the top. Therefore, if a simple lever, wheel, or working beam, is used for this secondary engine, No. 2, the engine ought only to be loaded with a column of water, or other work, equal to half the

number of pounds on each square inch which the primary engine, No. 1, is able to work with; but if the secondary engine, No. 2, is furnished with any proper contrivance for equalizing the power of the steam, it may, in case the cylinders of the two engines are of equal capacity, be made to do seven-tenths of the work which is done by the primary engine, No. 1. When the piston of the secondary engine, No. 2, has come to the bottom of its stroke, the middle regulating valve O is opened, and the steam rushes into the condenser G K, and in its way meets the jet of injection water, which condenses it; and thereby the upper part of the cylinder of the secondary engine, and the lower part of the cylinder of the primary engine, are exhausted of steam. The piston of the secondary engine, No. 2, having then a vacuum both above it and below it, is pulled up easily by the working beam of that engine; and, there being a vacuum under the piston of the primary engine, No. 1, the steam from the boiler exerts its power upon it, and presses it down, and the other motions are repeated, as has been described. These compound engines may also be wrought in other manners, of which I shall describe one of the best. Let the eduction pipe N be supposed to be removed, and a steam pipe S, (which is delineated in red ink),* be made to communicate between the perpendicular steam pipe C of the primary engine, and the top regulator box or cross pipe Q of the

* In Plate xvii., marked by faint dotted lines.

secondary engine; then the piston of the primary engine, No. 1, being pressed to the bottom by steam, shuts its top regulating valve D, and opens the top regulating valve Q of the secondary engine: the piston of that engine will immediately begin to descend with a decreasing power, (as has been remarked before). When the piston of the secondary engine, No. 2, has come to the bottom of its stroke, its middle regulator O is opened, whereby the steam rushes out of the cylinders of both the engines into the condenser or condensers; and, there being vacuum both above and below the pistons of both engines, the equilibrium of both is restored, and both the pistons are permitted to be raised by the unbalanced weight of the pump rods, or other weights or machinery applied for that purpose. It is proper, in this mode of application, to make a small pipe leading from the lower part of the cylinder of the primary engine to the eduction pipe, or condenser, of the secondary engine; whereby the vacuum under and above both pistons may be maintained of an equal degree of rareness or perfection. For the more clear understanding of these improvements and contrivances I have delineated them on the parchments hereunto annexed, according to scales specified on the respective drawings, and have adapted them all, except figure 1st,* to engines whose cylinders are thirty inches in diameter, and the whole length of the stroke of whose pistons is eight feet; but I

* See Plate viii.

make the cylinders larger or lesser, longer or shorter, and vary the proportions and shape of them and of the other parts, according as their uses may require; and as each improvement, method, piece of mechanism, or contrivance, admits of numberless variations, I have set forth and delineated only such as I esteem to be among the best, and which are the most easy to be executed.

My Fourth new Improvement on steam or fire engines consists in applying a certain mechanical contrivance, called a toothed rack and sector of a circle, or toothed racks and toothed sectors of circles, for suspending or connecting the pump rods or pistons with the working beams, levers, or other machinery used in place of them, in place or instead of chains, which have hitherto been used for these purposes. This new improvement, or mechanical contrivance, is delineated at O Q, figure 12th,* and requires no other explanation than to say that it is delineated by a scale of one-fourth of an inch to each foot of the real size, according to its proper dimensions for a cylinder thirty inches in diameter; and the said rack and sector are supposed to be made of hammered or cast iron, but it may be made of wood or other materials by giving it dimensions suitable to the strength of the material of which it is made; and, in order to accommodate the same to cylinders of other sizes, the strength of its parts must be increased or diminished, in proportion to the powers

* See Plate xv.

of the respective cylinders to which it may be applied. I have described and delineated all my aforesaid new improvements upon, and new mechanical contrivance applicable to steam engines, as applied to or connected with the new steam engines of my own invention, as being the most perfect hitherto made; BUT IT MUST BE REMEMBERED, that I do apply the same to the common steam engines known by the name of Newcomen's Steam or Fire Engines; and that they are also applicable to any other species or variety of steam engines which works with a piston moving in a cylinder or steam vessel; and that they will in such engines produce greater or lesser effects in proportion to the degree of perfection of the engine to which they are applied. It is also to be remarked, that though I have described all the engines standing erect, and having the piston rods coming through holes in the top of the cylinder, that the same or nearly the same effects will be produced, though the piston rods come through holes in the bottom of the cylinder, and the working beams or equalizing machinery be placed under them; or although the cylinders and working beams are placed inclined or horizontally; and that, in certain cases, I use them in such different positions.

MY FIFTH NEW IMPROVEMENT on steam or fire engines consists in making the steam vessels in the form of hollow cylinders, or in the form of other regular round hollow vessels, or in the form of greater or lesser segments or sectors of such bodies or vessels. And I place in the centre or axis of

the circular curvature of such vessels, a round shaft or axle, passing through and extending beyond one or both ends of such steam vessel; and I shut up the ends of the said steam vessel with smooth plates, which have proper apertures for the said axle or shaft to pass through; and within the said steam vessel I fix to the said axle a piston or plate, extending from the said axle to the circular circumference of the steam vessel, and also extending from one end of the steam vessel to the other. And I make the said piston steam-tight, by surrounding the parts which fit to the steam vessel with hemp, or other soft substances, soaked in grease, oil, or wax, or by means of springs made of steel, or other solid and elastic or pliable materials; and to the said steam vessel I fix one or more plates or divisions, extending from the axle to the circumference of the steam vessel; and, where these plates or divisions join to or approach the axle, or where the said axis passes through the end plates of the steam vessel, I make such joinings steam and air-tight, by the means above recited. In the steam vessel, on each side of the said piston, I make one or more channels or apertures for receiving and discharging the steam, which channels I furnish with proper valves for that purpose: I also apply to the said engine proper condensers and air pumps; and the pumps which raise water, or such other machinery as is required to be wrought by the said engine, are put in motion or worked by a wheel or wheels fixed to or upon the external parts of the said axle, or by any other mechanism which

may be suitable. And the said engine, so constructed, is wrought by admitting the steam between the fixed division and the moveable piston, and exhausting or making a vacuum on the other side of the said piston, which accordingly, by the force of the steam, moves into the said vacuum, and turns the axle a greater or lesser portion of a circle, according to the structure of the machine. The piston is returned to its former situation by admitting steam on the other side of the said piston, and drawing the piston back by some external power, or by exhausting the part of the steam vessel which was first filled with steam. An engine constructed upon this principle is delineated at figures 15th, 16th, and 17th in the annexed drawing,* according to a scale of one-fourth of an inch to each foot of the real size; but I make them greater or lesser, and vary the shape and size of the steam vessel and other parts, according to their use. The operation of the engine is as follows:— The steam vessel A A A being exhausted of steam and air, and the regulating valves K and J being shut, and L and H open, the steam coming from the boiler through the pipe M enters the steam vessel by L and G, and causes the piston C to turn round into or towards the exhausted part of the steam vessel A X, and thereby turns the axle B, and the machinery attached to it, until the piston C comes to X: the regulating valves L and H are then shut, and K and J are opened: the steam

* See Plate xviii.

Fig. 15th.

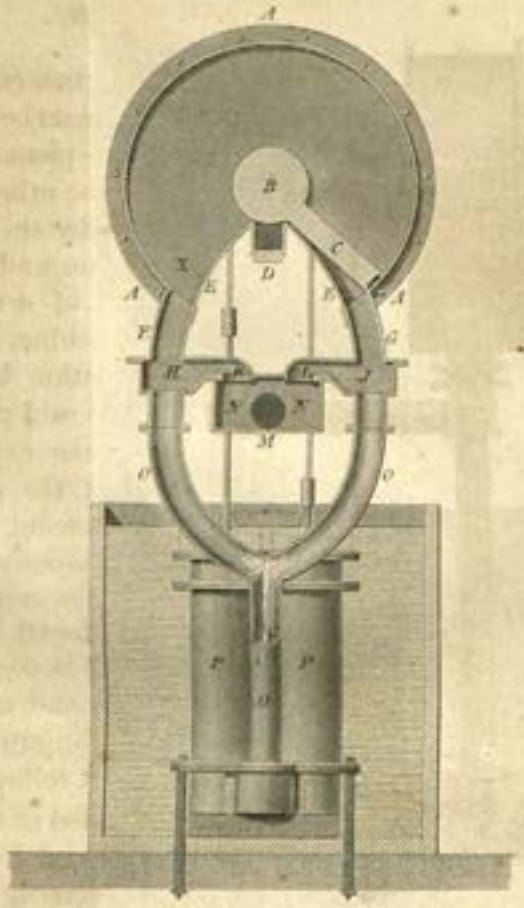


Fig. 16th.

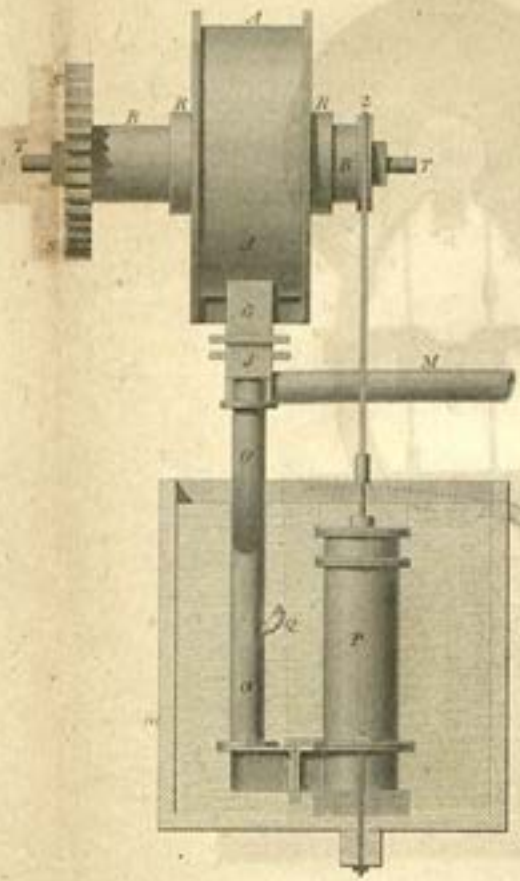
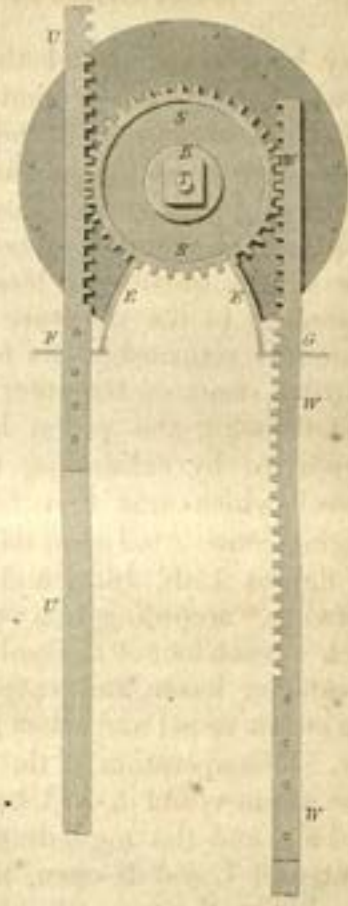


Fig. 17th.



J.W. Lowry fc.

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet

Figs. 15th, 16th & 17th. The New Reciprocating Semi Rotative Engine. Fig. 15th Section of the Engine at right angles to the axle of the Engine Cylinder. A A The hollow Cylinder cut open. B The Axle or Axis. C The Piston. D A Box filled with some soft substance to make the joining of the division Plates. E E. with the Axle Steam and Air tight. F G. Pipes which admit and discharge the Steam. H K L J. Places or valves or Regulators. M The Steam Pipe from the Boiler. N N. The Steam Regulater Box. O O. The Eduction or Condenser Pipe. Q The Injection Pipe. P P. Condenser Pumps. Fig. 16th A side view of the Engine wherein the same letters are placed on the same parts as in Fig. 15th and R R are Sockets to make the Axle air tight and S S the Wheel which acts upon the pump rods. T The Wheel which works the Condenser. Fig. 17th Outside Front View of the Engine and pump rods. The Condenser and Regulator Boxes are not drawn in this view and the upper part of the pump rod U U is supposed broken off. T. The Pivot of the Axle. U U W W. The Pump Rods and their Racks.

John Murray, Albemarle Street, London. 1854.

Fig. 18th

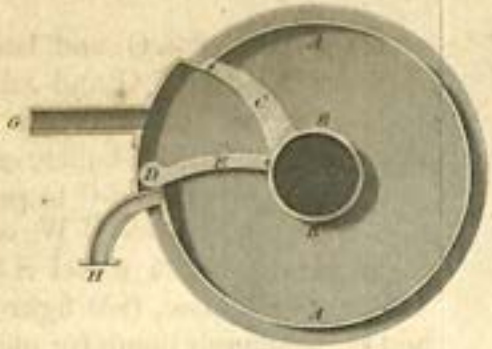


Fig. 19th

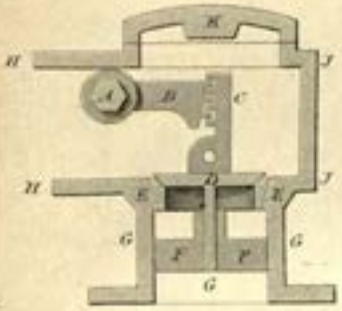


Fig. 18th A New Rotative Engine. The Steam enters by the Pipe G. and acts against the Valve E. and the moveable Radius or Piston C. and the space A.A. B.B. being exhausted, the Piston revolves through it by the action of the Steam, and turns the axle B B. when the Piston comes to the valve E. the pipe G is shut and the valve E opens by turning upon the joint D & so permits the Piston C to pass by it. The Steam then rushes into the Condenser by the pipe H, which exhausts the Steam vessel. When the Piston has got to its original place, the valve E is again shut, and the Steam admitted through the pipe G. into the Space between the valve E & the Piston C. and to continue the motion during the time that the piston is passing the valve a heavy fly is fixed on, or connected with some part of the axle B B. on the outside of the cyl.r The Outside Figure of this Engine is nearly the same as Fig. 16th But the Steam vessel may be placed either vertically as drawn or horizontally as its use may require.

Section of part of a Regulator Box or Nozle.

A Cross section of a Spindle, which comes through the side of the Box and moves the arm or Sector B. which acts upon the Rack C. which raises the regulating valve D. which is ground to fit the Seat E E. and is guided by the Socket F F. G G The Pipe which leads to the Condenser. K. A Cover which is opened occasionally to rectify the Valve. H H. J J. part of the Nozle.

J.W. Lowry sculp.

John Murray, Albemarle Street, London, 1854.

which had entered by the pipe G, and had acted upon the piston, returns through G and J into the condenser or eduction pipe O, where it is condensed; and the steam from the boiler, entering through K and F, forces the piston C to return to its first situation. The pump rods U W, or other machinery, are wrought by the wheel S S fixed on the axle B B, or otherwise, (see figures 16th and 17th);* and the condenser pump (or pumps) is wrought by the wheel Q, fixed to any part of the said axle, or otherwise. It is to be understood that the said steam vessel is to be firmly fixed, so that it cannot move; and that the gudgeons or pivots of the said axle must be rested upon proper supports, which things could not be exhibited in the drawing without confusion. I also cause engines, made according to this Fifth improvement, to revolve with a continued rotative motion, by making their steam vessels complete cylinders, or other circular figures; and, in place of the fixed division or divisions, I place one or more valves in their steam vessels, which shut or close the area between their axles and their circumferences, and which valves open by turning upon a hinge or joint, or are drawn back by a sliding motion like a drawer, or otherwise are constructed so that they may be removed when the piston comes to them, and thereby suffer it to pass by the place where they were, (see the drawing, figure 18th),† and so begin a new revolution in the same direction; or

* See Plate xviii.

† See Plate xix., figure 18th.

I make a fixed division, or divisions, as has been described, and I fix one or more valves to the axle, which valves are capable of folding down, and of applying themselves to the axle, and of forming a part of its circumference, so that they can thereby pass by the division; and, when they have passed it, they are raised up by springs, or otherwise, so as to perform the office of a piston or pistons. I have not described the boilers which supply any or all of these engines with steam, because I use such as are commonly applied to other steam engines, or any kind of boiler which is capable of producing steam in sufficient quantities. Neither have I described the machinery which opens and shuts the regulating valves, as it is similar to that which is in common use, and may be varied at pleasure.*

In Witness whereof I have hereunto set my hand and seal this third day of July, in the year of our Lord one thousand seven hundred and eighty-two.

James Watt.

Sealed and delivered, being first duly stamped, in the presence of

John Southern.
Peter Capper.

* This Article of the Specification having been unaccompanied by any relative drawing, the reader may be referred to Plate xxix., which is an engraving of a working model of a locomotive engine made by Mr. Murdock in 1784, on the principles specified by Mr. Watt, and the performance of which in practice was perfectly satisfactory. See vol. i., p. ccxxxvi. *supra*.

Acknowledged by the said James Watt, party hereto, the third day of July, one thousand seven hundred and eighty-two, before me,

GEO. HOLLINGTON BARKER,
A Master in Chancery Extraordinary.

INROLLED in His Majesty's High Court of Chancery, the fourth day of July, in the year of our Lord 1782, being first duly stamped according to the tenor of the Statutes made in the sixth year of the reign of their late Majesties King William and Queen Mary, and in the seventeenth year of the reign of His Majesty King George the Third.

4. P. Y. JOHN MITFORD.

SPECIFICATION OF PATENT, APRIL 28TH, 1784, FOR CERTAIN NEW IMPROVEMENTS UPON FIRE AND STEAM ENGINES, AND UPON MACHINES WORKED OR MOVED BY THE SAME.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Birmingham, in the county of Warwick, Engineer, send greeting.

WHEREAS His Most Excellent Majesty King George the Third, by His Letters Patent bearing

* This specification may probably be viewed as second in importance to none of those prepared by Mr. Watt subsequent to that of the Separate Condenser in 1769; as, besides many improvements now of minor consequence, such as steam-wheels, balancing of pump-rods, communication of motion from the same engine to two separate primary axes, and apparatus for opening the regulating-valves with rapidity, it contains various methods of converting a circular or angular motion into a perpendicular or rectilineal motion,—one of those methods being the well-known and much-admired *Parallel Motion*;—a method of working a tilt-hammer for forging iron, making steel, &c., by steam;—and the application of the steam-engine to give motion to wheel carriages for carrying persons or goods.

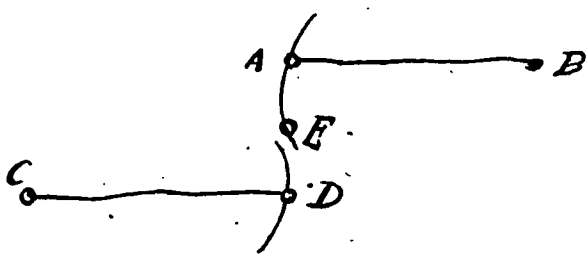
Of the last-mentioned invention, and of its inventor's views of the subject of locomotion by steam in general, we have already treated at what may probably be deemed sufficient length, (Introductory Memoir, vol. i. pp. ccxxxv.—ccxl.); and for particulars of the first experiments with the steam tilt-hammer, which has since become an instrument of such extensive utility, we may refer to Mr. Watt's letters of 26th, 28th, and 30th November; 3rd, 12th, 13th, and 14th December, 1782; and 3rd January, 26th March, 26th and 27th April, 1783, given in vol. ii. pp. 163—175, *supra*.

Of the invention of the Parallel Motion,—a mechanical puzzle which different philosophers have attempted to explain in various ways, but

date at Westminster, the twenty-eighth day of April, in the twenty-fourth year of his reign, did give and grant unto me, the said JAMES WATT, his especial licence, full power, sole privilege, and authority, that I, the said JAMES WATT, my executors, administrators, and assigns, should, and

which has uniformly commanded the admiration of all who either comprehend the principles on which it acts, or even merely behold the smoothness, orderly power, and "sweet simplicity" of its movements,—we find the following account in a letter from Mr. Watt to his son, already cited (Mr. Watt to Mr. James Watt, 10th November, 1808):—

"The idea originated in this manner. On finding double chains, or "racks and sectors, very inconvenient for communicating the motion of "the piston-rod to the angular motion of the working-beam, I set to "work to try if I could not contrive some means of performing the same "from motions turning upon centres, and after some time it occurred to "me that AB, CD, being two equal radii revolving on the centres B and



"C, and connected together by a rod AD, in moving through arches of "certain lengths, the variations from the straight line would be nearly "equal and opposite, and that the point E would describe a line nearly "straight, and that if for convenience the radius CD was only half of "AB, by moving the point E nearer to D, the same would take place, "and from this the construction, afterwards called the parallel motion, "was derived. * * Though I am not over anxious after fame, "yet I am more proud of the parallel motion than of any other "mechanical invention I have ever made." * *

See also, on the subject of this and several others of Mr. Watt's improvements on the steam-engine, his Appendix to Robison on Steam and Steam-engines, pp. 152 to 159.

lawfully might, during the term of years therein expressed, make, use, exercise, and vend, within that part of his Majesty's Kingdom of Great Britain called England, his Dominion of Wales, and Town of Berwick upon Tweed, my Invention of "CERTAIN NEW IMPROVEMENTS UPON FIRE "AND STEAM ENGINES AND UPON MACHINES "WORKED OR MOVED BY THE SAME;" in which said recited Letters Patent is contained a Proviso obliging me, the said JAMES WATT, by writing under my hand and seal, to cause a particular description of the nature of the said invention, and in what manner the same is to be performed, to be inrolled in His Majesty's High Court of Chancery within four calendar months after the date of the said recited Letters Patent, as in and by the said recited Letters Patent, and the Statute in that behalf made, relation being thereunto had, may more at large appear.

NOW KNOW YE, That in compliance with the said Proviso, and in pursuance of the said Statute, I the said JAMES WATT do hereby declare, that the nature of my said invention, and in what manner the same is to be performed, is particularly described and ascertained as follows, that is to say:—

MY FIRST NEW IMPROVEMENT on steam and fire engines consists in making the steam vessel so as to be capable of turning round on pivots or on an axis, either in a vertical or horizontal direction, and in employing the elastic power of the steam to press upon the surface of any dense fluid or liquid contained in the steam vessel, and to force it to

Fig. 1st.

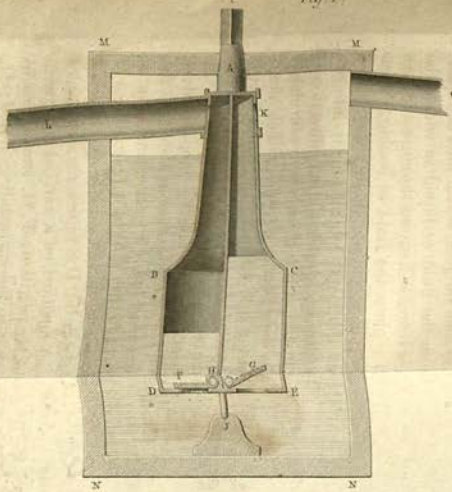


Fig. 2d.

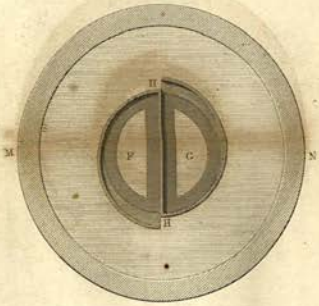


Fig. 3d.

John Murray, Albemarle Street, London, 1854.

J.W. Lowry fc.

pass out at a hole or holes made in the circumference or external part of the steam vessel, in such manner that the fluid or liquid shall issue out in a line forming a tangent to the circle described by the rotation of that part of the steam vessel where the hole is situated, or at least in a line approaching to such tangent, which fluid or liquid, by its action on the fluid or liquid in which the steam vessel is immersed, causes the engine to turn round; and I replace the fluid so issuing, by immersing the steam vessel into another vessel filled with the same fluid, and by dividing it into two or more divisions or chambers, in the direction of its axis of rotation; which chambers are furnished with valves in their bottom or sides, which admit the fluid to enter into one of them, while by the force of the steam it issues from another, and the steam is admitted into these chambers, and its action is suspended alternately by proper valves and regulators, which are opened and shut by the rotation of the machine. The machine may be made in various forms: I have delineated one of the most commodious in figure 1st of the annexed drawing,* where A B C D E represents a section of the steam vessel mounted on a vertical axis, with one perpendicular partition; F, G, two valves in its bottom, to admit the surrounding liquid; H, the place of one of the holes at which it issues; J, the pivot on which it turns; K, a collar which is fitted exactly to the neck of the steam vessel, so as to be steam-tight, and yet to give liberty to the

* See Plate xx., figure 1st.

vessel to turn round in it freely; L, a pipe conveying steam from a boiler to the steam vessel, and which is joined to the collar. There are two holes in the neck of the steam vessel which communicate with its two chambers, and, as the vessel turns round, present themselves alternately to the opening of the steam pipe within the collar, and to an opening on the opposite side of the collar, which communicates with the empty part of the vessel M N, which contains the liquid in which the steam vessel is immersed. The vessel M N is made of a cylindric or other form, and contains a quantity of quicksilver, water, oil, or other fluid or liquid, of a depth sufficient to give a resistance to the issuing fluid proportioned to the effect wanted to be produced, and to cause the fluid to fill the empty chamber of the steam vessel in proper time. If the machine is required to act only by such steam as has a greater expansive force than the pressure of the atmosphere, this vessel M N is opened at top, and the steam which has done its office is then discharged into the open air; but when the steam is required to act with the pressure of the atmosphere, in addition to its own elastic force, then the vessel M N must be shut at top, and made everywhere air-tight, and the steam be made to pass from it by the pipe O into another vessel, called a condenser, where it is condensed by the application of cold water, or other cold bodies, by which means a vacuum is obtained, and the power of the steam is augmented. Figure 2nd* is a ground

* See Plate xx., figure 2nd.

plan of the steam vessel, and of the external vessel; H H are two apertures at which the fluid alternately issues, and F G are the valves by which it enters. Figure 3rd * is a horizontal section of the collar and of the neck of the steam vessel, in which R R are the two apertures which admit and discharge the steam, and L the steam pipe coming from the boiler. The action of the machine is as follows: Steam being admitted into one of the chambers, causes the fluid contained in it to issue with violence at the lower aperture belonging to that chamber, and the fluid so issuing, by its action against the quiescent fluid contained in the outer vessel, causes the steam vessel to turn round; by which means the upper aperture of the other chamber is presented to the steam pipe, and the action on the fluid in that chamber commences; at the same time the steam issues at the upper aperture of the first chamber, and it is replenished by the fluid entering by the valve at the bottom. The machinery to be worked by the engine is put in motion by being attached, fixed to, or connected with the end of the axis P, which passes through a hole or collar in the cover of the outer vessel M N. This engine is delineated by a scale of one inch for each foot of the real size, but may be larger or lesser, and its proportions varied at pleasure.

My Second new Improvement on the steam engines consists in methods of directing the piston rods, the pump rods, and other parts of these

* See Plate xx., figure 3rd.

engines, so as to move in perpendicular or other straight or right lines without using the great chains and arches commonly fixed to the working beams of the engines for that purpose, and so as to enable the engine to act on the working beams or great levers, both by pushing and by drawing; or both in the ascent and descent of their pistons. I EXECUTE THIS ON THREE PRINCIPLES: THE FIRST PRINCIPLE is delineated in figure 4th,* and is performed by connecting with the top of the piston rod A by means of joints, two secondary levers or beams B C, the other ends of which are furnished with arches D E, which roll upon the walls of the house F G, or on pieces of timber or other proper resisting bodies fixed at convenient distances parallel to the line of motion of the rod which is required to receive the right-lined or perpendicular motion; and these arches are suspended in their places by means of leather belts, chains, or jointed bars of iron, attached to them. The top of the piston or pump rod, and the working beam, are also connected together by means of a piece of iron or wood H, having a joint at each end, on which it can move freely and accommodate itself both to the angular motion of the working beam J J and to the perpendicular motion of the piston or pump rod. THE SECOND PRINCIPLE by which I produce a right-lined motion from an angular or circular motion is delineated in figures 5th and 6th,† and consists in guiding the top of the piston rod or

* See Plate xxi., figure 4th.

† See Plate xxi., figures 5th and 6th.

Fig. 4th

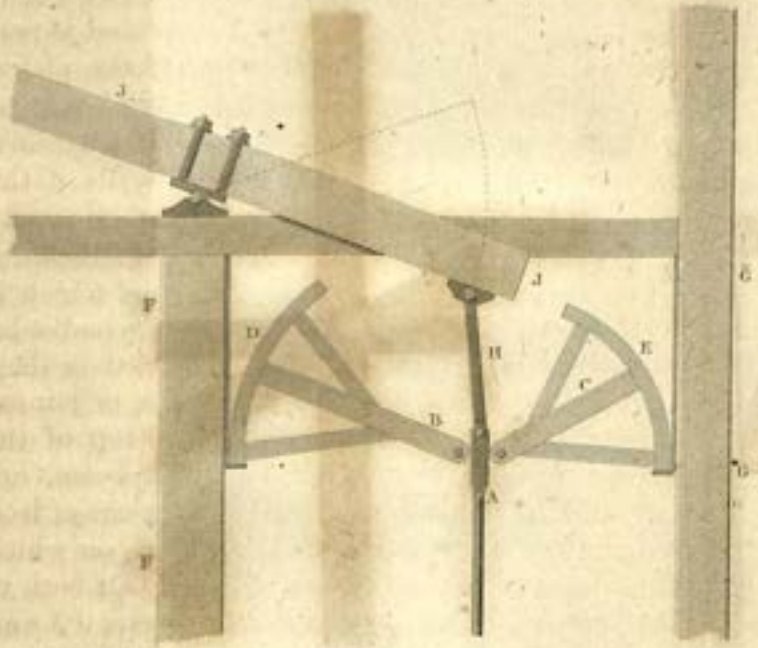


Fig. 5th

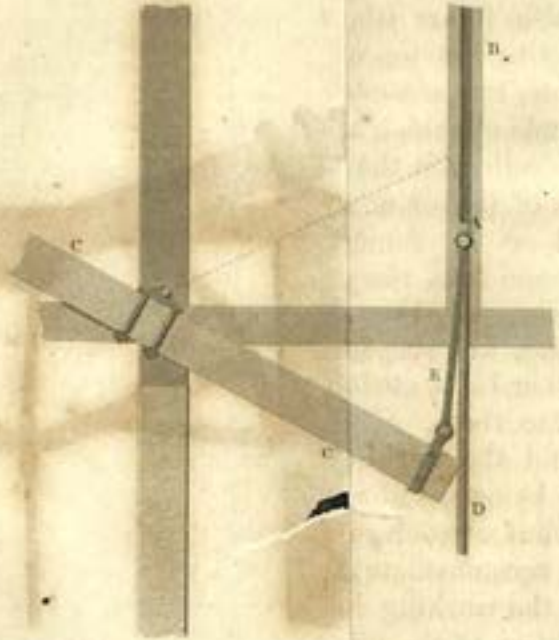
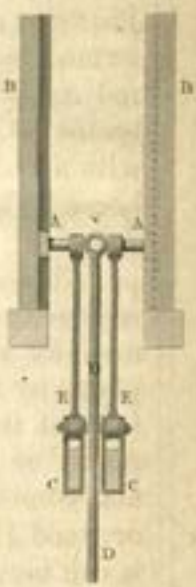


Fig. 6th



J.W. Lowry fc.

John Murray Albemarle Street London 1854

pump rod perpendicularly by means of a piece of wood or iron, or other material A, sliding in a groove made in an upright B, firmly fixed to some part of the machine, so as to be higher than the working beam C, and in the direction of the required motion, and by connecting the end of the working beam with the top of the piston rod or pump rod D, or with the said sliding piece A, by means of a bar or bars of wood or iron E, having joints at each end. Figure 6th shows an end view of the working beam, piston rod, sliding piece, and connecting bars; and the pricked circular and angular lines, figure 5th, show the quantity of angular motion of the working beam. In figure 19th* is delineated another method of using this principle: A A is the piston of the engine, which has a hollow piston rod B B, and the connecting bar C C is attached to the bottom of that hollow rod by means of a joint, and to the working beam by means of another joint, and the hollow piston rod, by sliding in the collar D D, serves to direct the motion, and the hollow rod is made wide enough to permit an angular motion of the connecting bar, proportioned to the versed sine of the angle described by the working beam. THE THIRD PRINCIPLE upon which I derive a perpendicular or right-lined motion from a circular or angular motion consists in forming certain combinations of levers moving upon centres, wherein the deviation from straight lines of the moving end of some of these levers is compensated by similar deviations, but in

* See Plate xxviii. figure 19th.

the opposite directions, of one end of other levers. In figures 7th and 8th* is delineated one Method of putting this principle into practice: A A represents the working beam of the engine; B, the wall or support on which it rests; C C, the spring beam; D E, a lever or bar of iron, moveable about the axis or centre D, (which is fixed to the spring beam), and also about the axis or centre E, which is connected with, or is a part of, the bar or rod E F. The bar E F is capable of sliding towards or from the axis or centre of the working beam by a sliding motion between a pair of cheeks at E, and by a portion of a circular motion of the end F round the centre H, from which it is suspended by the coupling bars or links H F. The piston rod or pump rod G is fastened to the bar F E and to the link H F by the joint pin at F. The right line F L is that in which the piston rod or its end F moves upwards and downwards. K M is a portion of a circle described from the centre of the working beam to which L F is a tangent, and K L and M F show its greatest deviations from the straight line or tangent. E N J is a portion of a circle described on the centre D by the joint pin E, and the length of D E and the situation of the centre D are such that the lines J L, N O, E F, are equal, and are represented by the rod E F; therefore, whenever the working beam is moved on its centre, the cheeks at E and the joint at F oblige the bar E F to move upwards or downwards along with it. But the centre D being fixed, the end E

* See Plate xxii., figures 7th and 8th.

Fig. 7th.

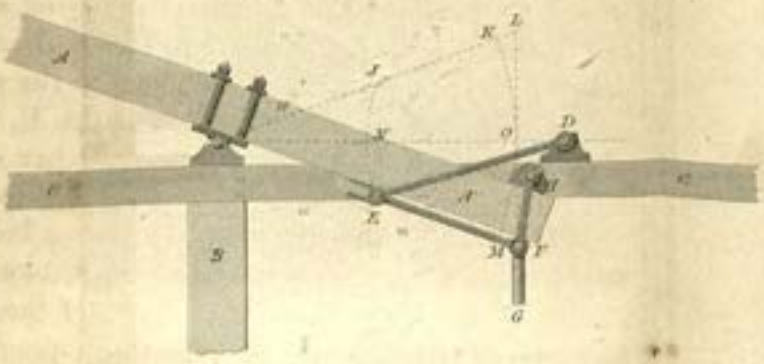


Fig. 8th.

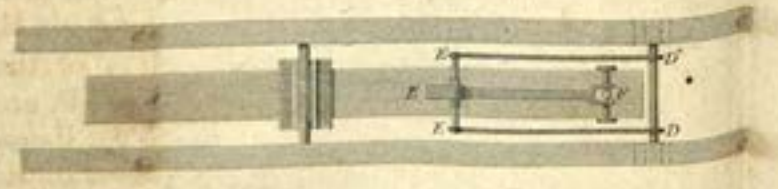


Fig. 9th.

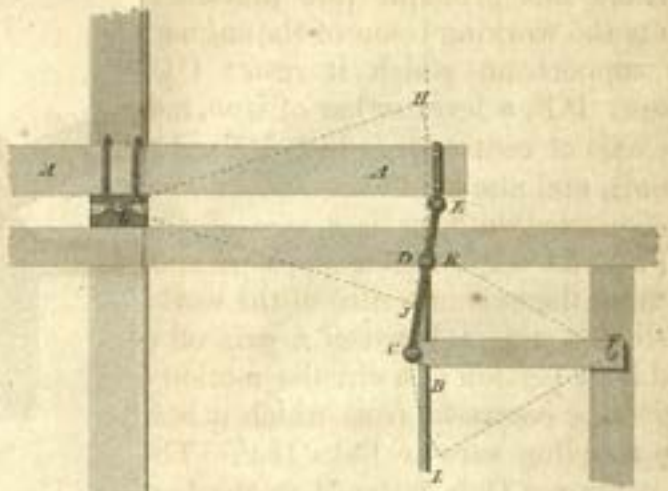


Fig. 10th.

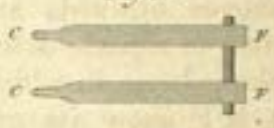
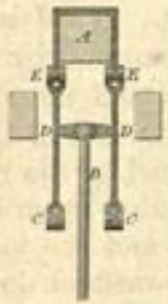
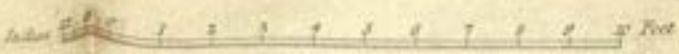


Fig. 11th.





J.W.Lowry fc.

John Murray, Albemarle Street, London, 1854.

of the rod E D can only move in the circle E N J, and the joint pin E obliges the rod E F to slide under the working beam between the cheeks, and to come nearer to the centre or to recede from it, according to the position of the working beam. And as the distances between every point of the arc J N E and the corresponding points of the line L O F are always equal, the point or joint F, together with the top of the piston rod, must move in the straight line L O F. In figure 8th is delineated a view of the underside of the working beam, seen from below, in which it is shown that the bar E D is made double, in order that one part may go on each side of the working beam, and that the joint pins E, D, and F, reach from side to side of the beam. Though the apparatus is in these drawings placed below the working beam, and that beam is fixed above its own axis or gudgeon, yet the contrivance will answer equally well if the whole were reversed, or if the rod E F and the axis of the working beam were placed in the middle of its depth by making the beam double. The proportions of the lengths and thicknesses of the parts to one another are such as answer in practice, but may be considerably varied, provided the principle be attended to. In figures 9th, 10th, and 11th,* I have delineated another Method, whereby I carry this third principle into practice. A A represents the working beam of an engine; B D, the piston rod or pump rod; C D E, one of

* See Plate xxii., figures 9th, 10th, and 11th.

two bars of iron or wood, connected, by joints at E and D, with the working beam and with the top of the piston rod respectively, and at C, by a joint, to an angling bar or bars C F, the other end or ends of which is or are connected with the wall of the house, or some firm support, by a joint or joints at F, on which, as a centre, the bar C F is moveable. When the working beam is put in motion on its axis, the point E describes the arc H E J, and the point C describes the arc K C L on the centre F, and the convexities of these arcs, lying in opposite directions, compensate for each other's variations from a straight line; so that the joint D at the top of the piston rod or pump rod, which lies between these convexities, ascends and descends in a perpendicular or straight line. The respective lengths of the radii G E and C F and their proportions to one another may be varied, but if the radius C F be lengthened more in proportion than G E, the point D must be placed proportionably further from E and nearer to C, and vice versâ, as is pointed out by geometry. The regulating radius or rod C F may also be placed above the working beam, and the latter may be reversed in regard to its own axis, where such construction is found more convenient. In figure 10th I have delineated a horizontal view of the radii C F, and in figure 11th an end view of the working beam A and the connecting bars E D C with the piston rod B B. In figure 12th* I have delineated another Method,

* See Plate xxiii., figure 12th.

Fig. 12th.

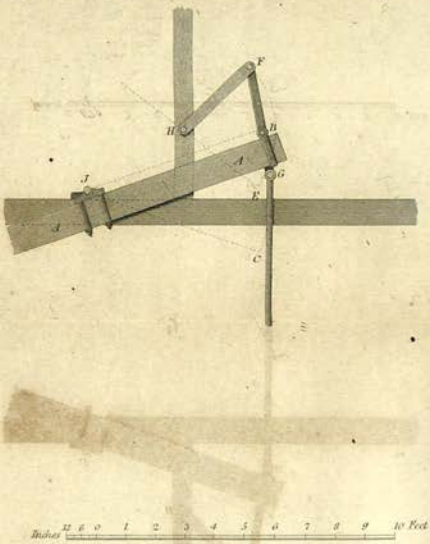


Fig. 13th.

J.W.Leury fc.

John Murray, Albemarle Street, London. 1854.

whereby I put this third principle into practice. The regulating radius F H being centred at H on a firm support, and the connecting bar F B G being connected with the working beam by a joint at B, is prolonged to G, where it is connected with the piston rod or pump rod G C by another joint. As the radius F H is shorter than the radius J B, the parts of the connecting rod F B, B G are so proportioned to one another, that on account of the difference of the convexities of the arches F E and B C, the point G and the piston rod G C will always ascend and descend in a perpendicular or straight line. This machinery also admits of being reversed; that is, the regulating radius H F may be placed under the working beam, and the working beam above its own centre of motion, in cases where that is found more convenient. This third principle may also be put in practice by other methods, but those delineated are in general the most eligible: all of them are laid down by a scale of one-fourth of an inch for each foot of the real size, in their proper proportions for engines whose cylinders are twenty inches in diameter, and the length of whose stroke is four feet; except figures 5th and 6th,* which are delineated for a six feet stroke; and figure 19th,† which is laid down for a cylinder fifteen inches in diameter and twelve inches length of stroke; but all the dimensions admit of considerable variation, according to the exigency of the case, and, preserving the propor-

* See Plate xxi. † See Plate xxviii.

tions, are applied to cylinders of different diameters and lengths of stroke.

My Third new Improvement is upon the application of steam or fire engines to work pumps or other alternating machinery. It consists in causing, by proper machinery, one half or one part of the pump rods to ascend while the other descends, whereby the weight of the pump rods, and other moving parts, always nearly balance one another, and the necessity of employing other matters to balance their weights, which are frequently enormous, is avoided. It is particularly applicable to engines which act forcibly both by the ascent and descent of the piston in the cylinder, but may also be advantageously employed to engines which act forcibly by the motion of the piston in one direction, as in such cases the weight of one set of pump rods may be employed, during their descent, to pull up the rods of other pumps, and thereby to work them: I perform this in various methods, of which I have delineated two of the best.* The First of these consists in suspending one-half, or part of the pump rods, to one end of a lever or working beam; and the other part, or half, to the other end of the same lever, which lever or working beam is supported on a centre or axis in some part of its length between the two rods, and the said rods are connected with or suspended to or from the said double lever by means of simple joints or by means of chains and

* See Plate xxiii., figure 13th; and Plate xxiv.

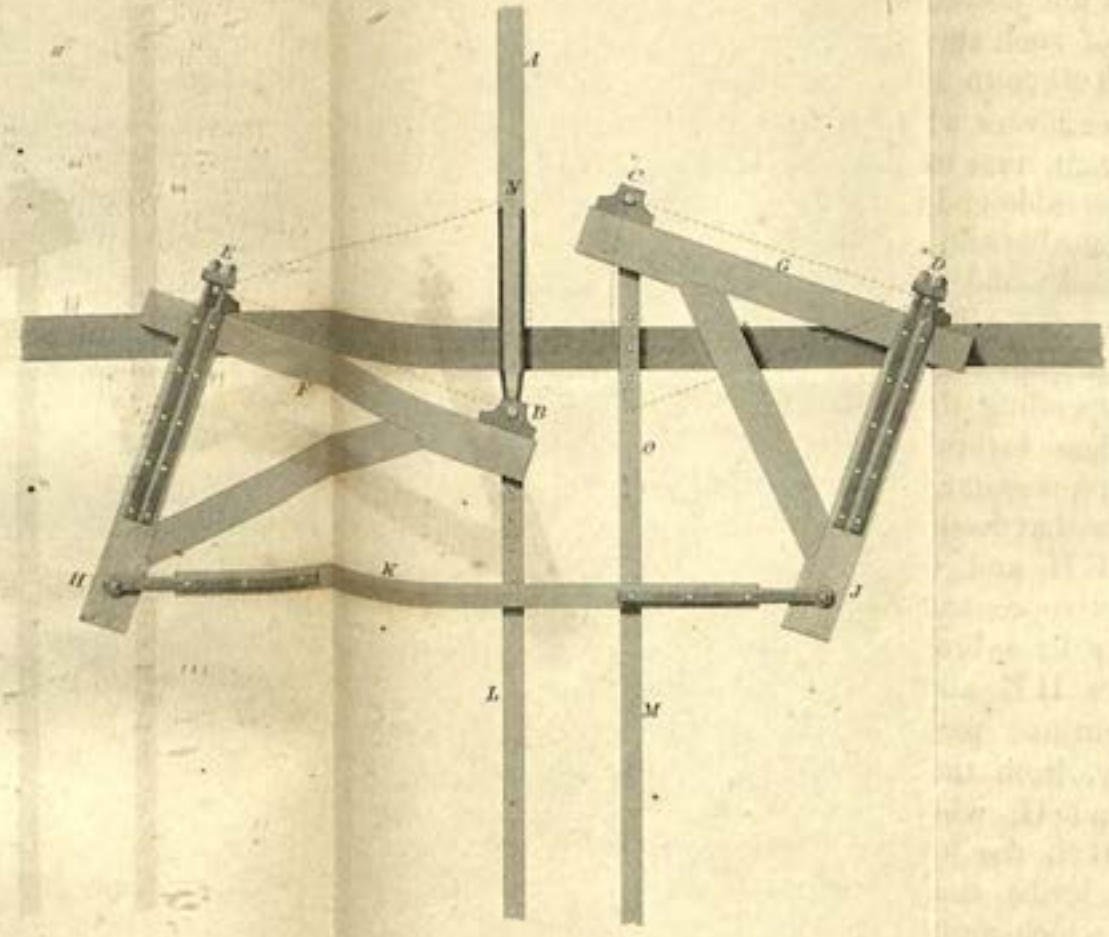
arches, or, in place of a lever, a wheel and chain may be used. The said lever may either be the working beam of the engine, or a separate lever placed over, or within, the mouth of the pit or shaft, and receiving its motion either directly from the piston rod of the engine, or from the working beam by means of a stiff rod; or, in case of the engine being of that kind which acts only in one direction, by means of a chain or rope. In figure 13th,* A A represents the double lever; B, its centre or axis; C L and D M, two rods of wood or iron, or two chains connecting this beam with the pump rods, which pump rods are suspended to the joints M L. K K represent two wheels which serve to guide the rods, and to bring them nearer together than they would naturally hang, in cases where the connecting rods C L, D M cannot be admitted to hang perpendicularly under the ends of the double lever; and J represents the lower end of a stiff rod, reaching from the working beam, or other moving part of the engine, and connected with the double lever A A by means of the joint H. AND BE IT REMARKED, that in cases where the connecting rods C L, D M are kept from their perpendicular position by means of wheels, (such as K K), the lower ends M L of these rods would describe curved or angular lines, which would disturb the perpendicularity of the pump rods suspended from these points. In order, therefore, to avoid such defect, I form the lower part of these connecting rods into curves, as

* See Plate xxiii., figure 13th.

shown in the drawing, which curves, acting against the wheels K K, compensate for the irregularities which would otherwise take place, and cause the points L and M, and the pump rods which are attached to them, to ascend and descend in perpendicular lines: (the figure of such curve is readily found by geometry). THE SECOND METHOD consists in connecting together levers which turn or move on separate or different axes or centres, in such a manner, that the moveable end of one lever shall descend when the moveable end of the other lever ascends, and vice versâ; and in connecting the moveable end of one of these levers with the working beam or piston of the engine in some proper manner, and in suspending the pump rods to the moveable ends of these levers by means of joints or chains. No. 14* represents a combination of levers which comes under that description. The two similar frames B F E H and C G D J, are moveable on their respective centres E and D, and are connected together by a brace or braces H K J, so that the pieces H E and J D must, when put in motion, continue parallel to one another; and consequently, from the positions of the pieces or levers F and G, when the joint pin B describes the arc B N, the joint pin C of the other frame must describe the arc C O in the opposite direction, by which means the pump rod L ascends when the pump rod M descends, and vice versâ; and these frames are connected

* See Plate xxiv.

Fig. 14th



J.W.Lowry sculp.

John Murray, Albemarle Street, London, 1834.

with the engine, or its working beam, by means of the rod or chain A B; or in place thereof, one of the levers F or G is prolonged on the other side of their respective centres E or D to a sufficient length to become itself the working beam of the engine. And the whole of this machinery may be reversed or placed upside down: that is, the levers E H and D J, with the brace or braces H K J, may be placed above their centres E and D instead of being placed below them, and may also upon the same principle be varied in other manners. The machinery delineated in figures 13th and 14th is laid down by a scale of one-fourth of an inch for every foot of the real dimensions, and is adapted for cylinders of twenty inches diameter and four feet stroke; but machinery on the same principles is made for larger or lesser engines, as required.

My Fourth new Improvement consists in new methods of applying the power of steam engines to move mills for rolling and slitting iron and other metals, or to move other mills which have many wheels which are required to turn round in concert, so that the same steam or fire engine shall directly, by means of a double working beam, or by means of a strong piece of wood or other material fixed across one end of the working beam, and by means of two separate rods connecting the said working beam or cross beam with proper machinery for producing rotative motions, give motion to two primary wheels fixed either on the same or separate axes, whether acting in concert or applied to different uses; and in connecting

together, by means of a secondary axis carrying two or more wheels, different primary motions produced by the same engine, or by two or more different engines, which methods are particularly applicable to the connecting together the motions of the rollers and slitters, or of different pairs of rollers, in mills for rolling and slitting metals, which are worked by fire or steam engines. In figures 15th, 16th, and 17th* is delineated the application of this improvement to a slitting mill, which drawings exhibit that machine in three different views, in all of which the same parts are marked with the same letters. Figure 16th is a section of the mill through the line XX of figure 17th, except in what relates to the working beam A B, the cross beam C, and the upper ends D E of the two connecting rods of the rotative motions. In order to avoid confusion, the rod E is represented as broken off, and the remaining part of it and the position of the rotative motion which it works are represented by the red ink lines and circles Q and R.† F is the revolving wheel of a rotative motion, which is fixed to the rod D, and G G is the centre wheel of the same motion, which is fixed upon the axis of the fly wheel J J and of the toothed wheel K K, to both which it gives motion, and also to the lower set of the slitters which are turned by that axis. The toothed wheel K K acts upon and gives motion to another toothed

* See Plates xxv. and xxvi.

† In the engraving, Plate xxv., represented by faint dotted lines.

Fig. 16th

Section of the Mill through the line X.X of Fig. 17th

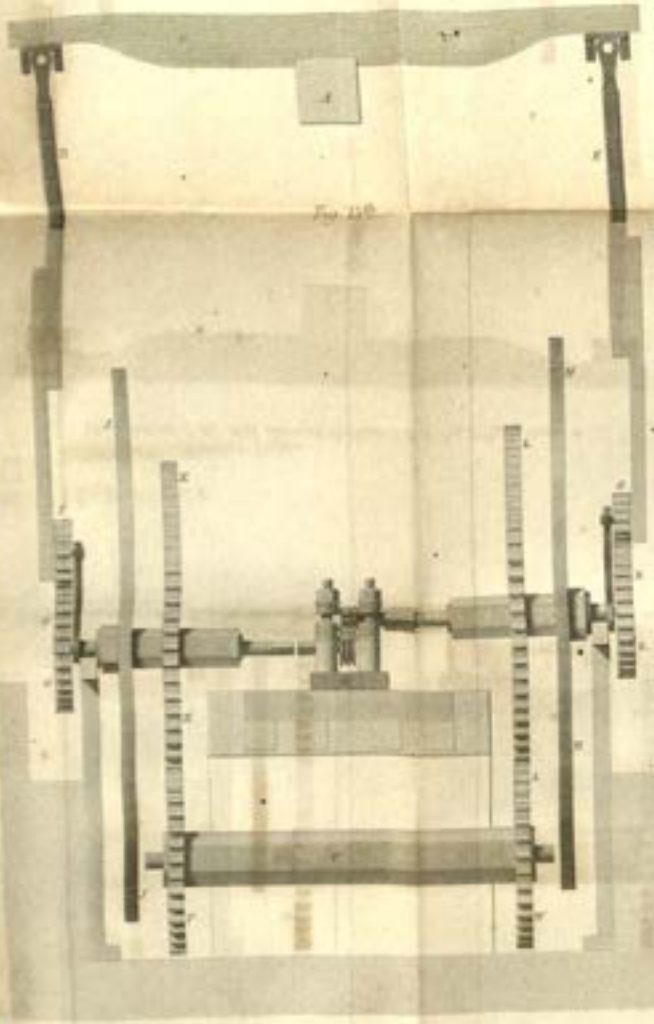
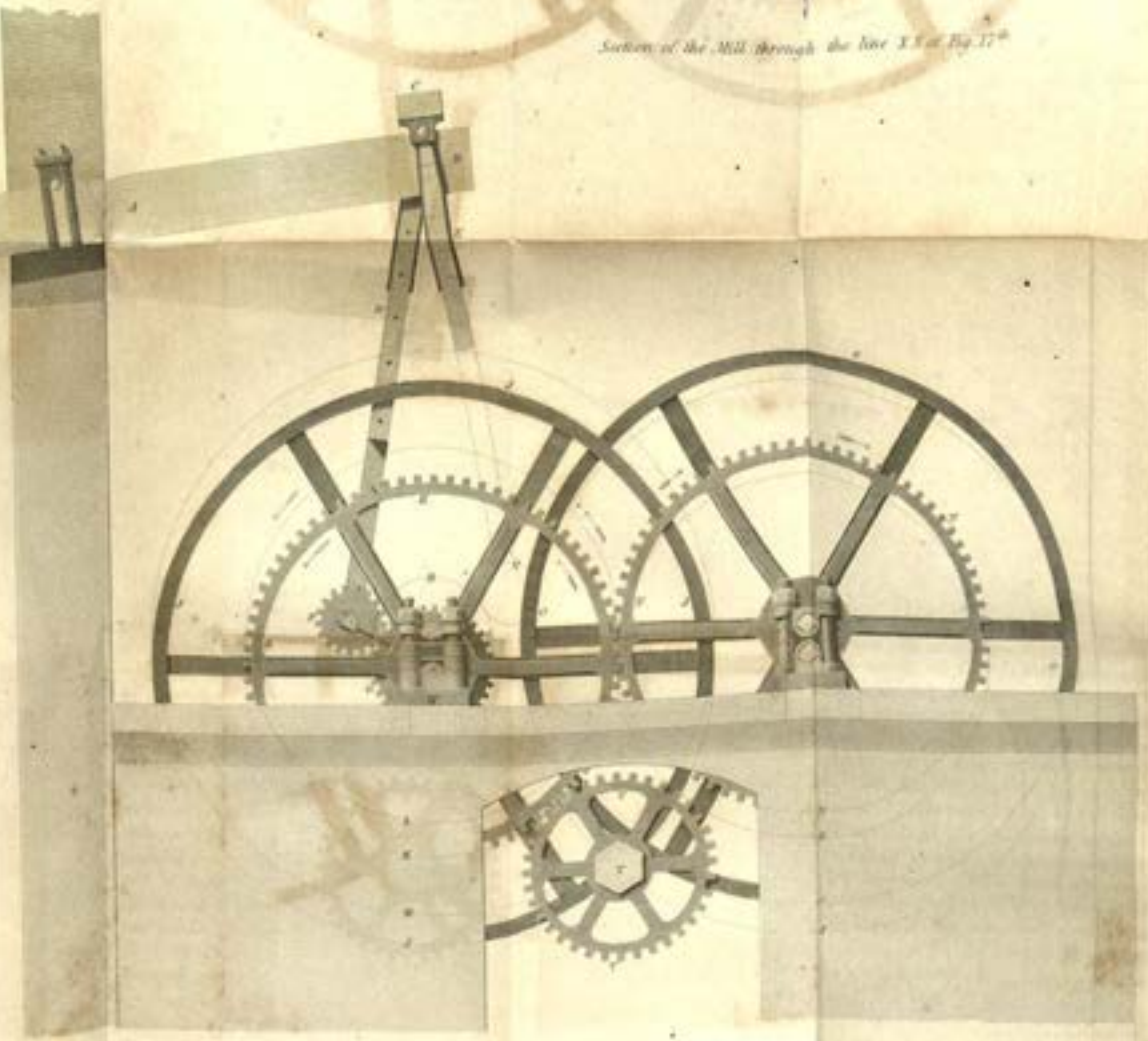


Fig. 15th

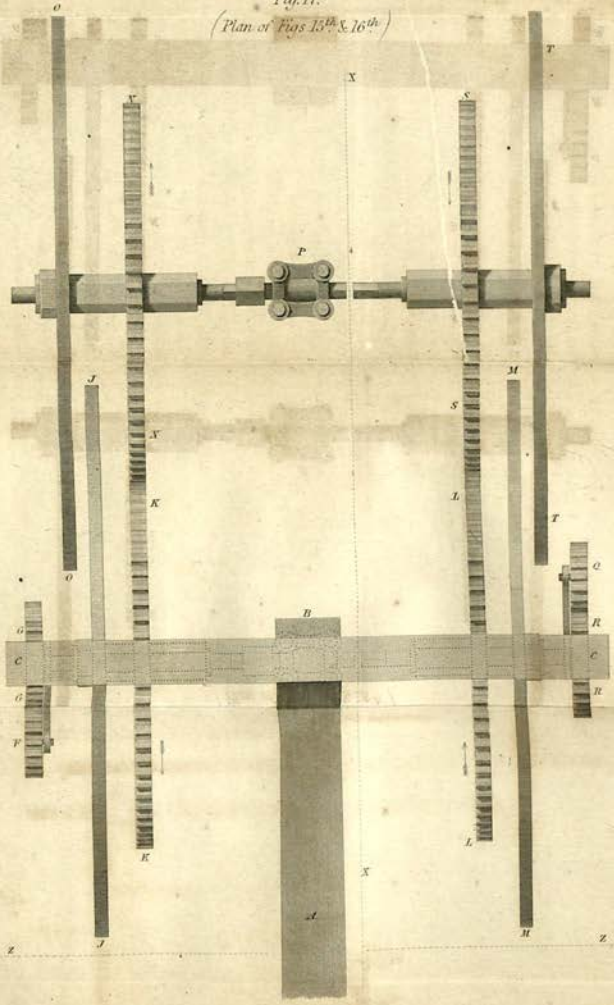


Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Feet

J.M. Gandy fc

John Harris, 3 Chancery Lane, London, 1834.

Fig. 17th.
(Plan of Figs 15th & 16th)



J.W. Lowry fc.

Inches 12 6 0 1 2 3 4 5 6 7 8 9 10 Feet

John Murray Albemarle Street London 1834

wheel N N, which is fixed on the same axis with the fly wheel O O, which turns the upper roller in the roll frame P, and the direction of the motion of these and the other wheels is shown by the darts. And the rod E, with the rotative motion Q R, (figures 15th and 17th), turns the fly wheel M M, and the toothed wheel L L, which is upon the same axis with that fly, and which axis also turns the upper set of the slitters. The toothed wheel L L acts upon and turns the toothed wheel S S and its fly wheel T T, and their axis turns the lower roller. The motion is thus communicated to all the wheels and flys, and also to both the rollers and slitters. But as the flys J J and T T must turn in the opposite direction to the flys M M and O O, and as there is nothing in the rotative motions themselves that can determine these wheels to take contrary motions at first setting out, and as at the top and bottom of the motion of the connecting rods D and E, and the revolving wheels which are fixed to them, the necessary shake in the teeth of the wheels of the rotative motions will permit the fly wheels on one side of the mill to run faster than those on the other, which produces a very prejudicial effect on the whole machine, I have contrived to connect the toothed wheels K K and S S together, by means of the toothed wheels V and W, fixed on the secondary axis Y under the other machinery: the teeth of the wheel V are engaged into the teeth of the wheel K, and the teeth of the wheel W are engaged into those of the wheel S; so that W and V being on the same axis, cause K

and S to turn in the same direction, and consequently L and N to turn in the contrary direction, and the whole wheels to move in an uniform manner. In place of the cross beam C, two working beams may be used, united together at the ends which are next the cylinder, and opening to the proper distance at the other ends like the letter V, and one of the connecting rods may be suspended to one of these beams, and the other rod to the other beam. In other cases, where the power required is not very great, I construct slitting mills with engines which have only one working beam and one set of machinery for producing a rotative motion, which is connected with the axis of one of the fly wheels, from whence the motion is transmitted to the other parts of the machines by the toothed wheels K K, L L, N N, and S S, and by the secondary axis Y and its toothed wheels V and W. The whole of this machinery is drawn in its due proportions, to a scale of one-fourth of an inch to each foot of the real size, to be moved by an engine with a cylinder of forty-eight inches diameter and six feet length of stroke, but it is made larger or lesser, as required. BE IT REMEMBERED, that although in order to explain my said Fourth new improvement, I have been obliged to delineate the whole of a slitting mill, yet that the new improvements which are the subjects of this article of the Specification, are only, the communicating the motion from the same steam or fire engines to two separate primary axes or shafts and sets of wheels moving in the same or in contrary

directions; and in connecting together four or more sets of wheels by means of secondary axes or shafts carrying two or more wheels each, such as the shaft or axis Y and its wheels V and W; both which improvements are, to the best of my knowledge, entirely new. In figure 20th* I have delineated the machinery by which the rotative motion is in this case proposed to be communicated from the working beam of the engine to the mill-work, (which is one of the methods described in the Specification of certain Letters Patent which his present Majesty was most graciously pleased to grant to me, bearing date the twenty-fifth of October, in the twenty-second year of his reign). But this drawing is only intended for elucidation, for I apply to this purpose not only the rotative machinery now delineated, but also any other kind which is proper or suits the particular case.

My Fifth new Improvement consists in applying the power of steam or fire engines to the moving of heavy hammers or stampers, for forging or stamping iron, copper, and other metals or matters, without the intervention of rotative motions or wheels, by fixing the hammer or stamper, to be so worked, either directly to the piston or piston rod of the engine, or upon or to the working beam of the engine, or by fixing the hammer or stamper upon a secondary lever or helve, and connecting the said lever or helve by means of a strap, or of a strong rod, to or with the working beam of

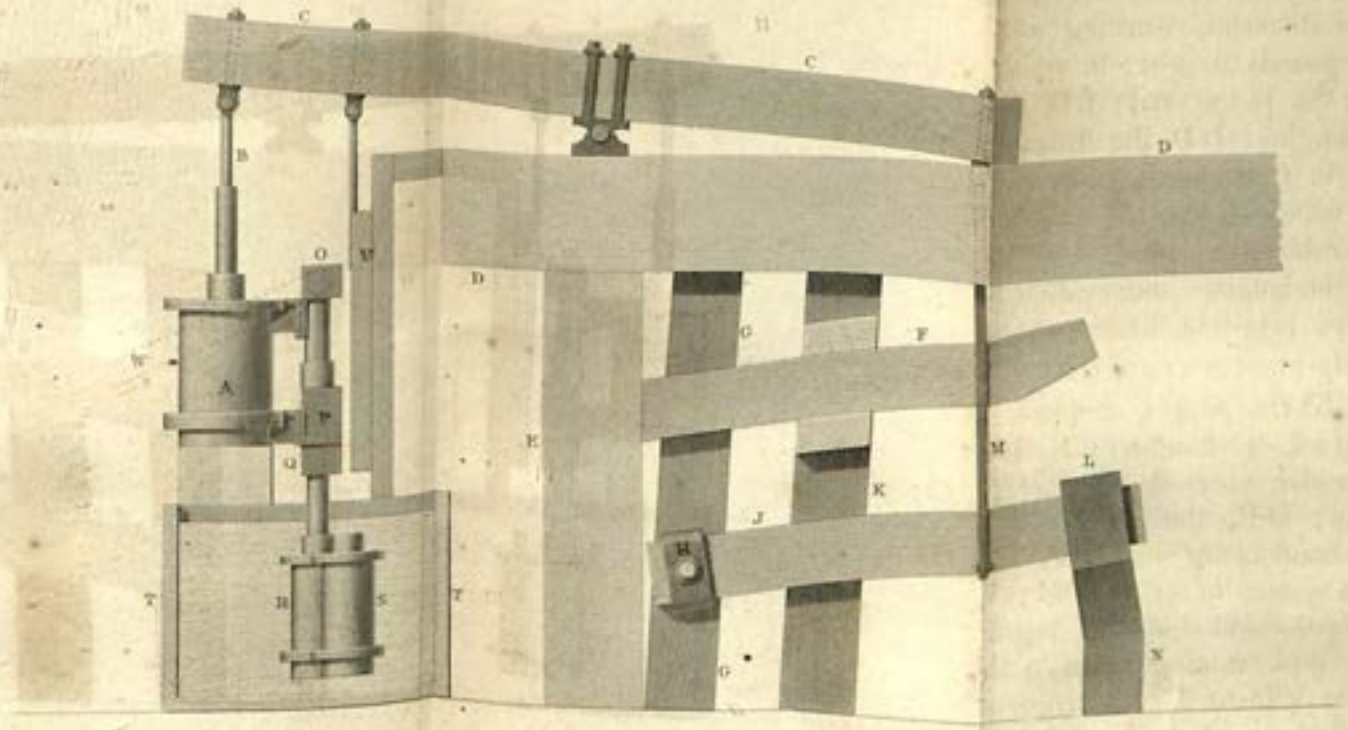
* See Plate xxviii., figure 20th.

the engine, or to or with its piston or piston rod. In figure 18th* is delineated, on a scale of one-third of an inch for each foot of the real size, a view of an engine of my invention, with a cylinder of fifteen inches diameter, working a hammer of five hundred pounds weight: in which, A is the cylinder; B, the piston rod; C C, the working beam of the engine; D D, the drom beam of the forge, which in this case is made double; E, a strong post, which carries the end of the drom beam; F, the rabbit or spring piece which regulates the ascent of the hammer and beats it back; G G, one of the two legs which carry the axis of the hammer; H, the hurst or axis of the hammer helve; J, the helve; K, the puppet or piece which supports the rabbit; L, the hammer; N, the anvil, and M, the rod which connects the helve with the working beam; O P, the nozzles or regulator boxes; R, the condensing vessel; S, the condenser pump; T T, a cistern of cold water; V, the plug frame which opens and shuts the regulators; and W, a steam pipe coming from a boiler. In figure 19th † is delineated, on a larger scale, a section of the cylinder, and a view of the apparatus by which, in cases where the engines are required to be worked very quick, the regulators are opened and shut; which shall be described in the next section.

My Sixth new Improvement consists in making the regulating valves which admit the steam into

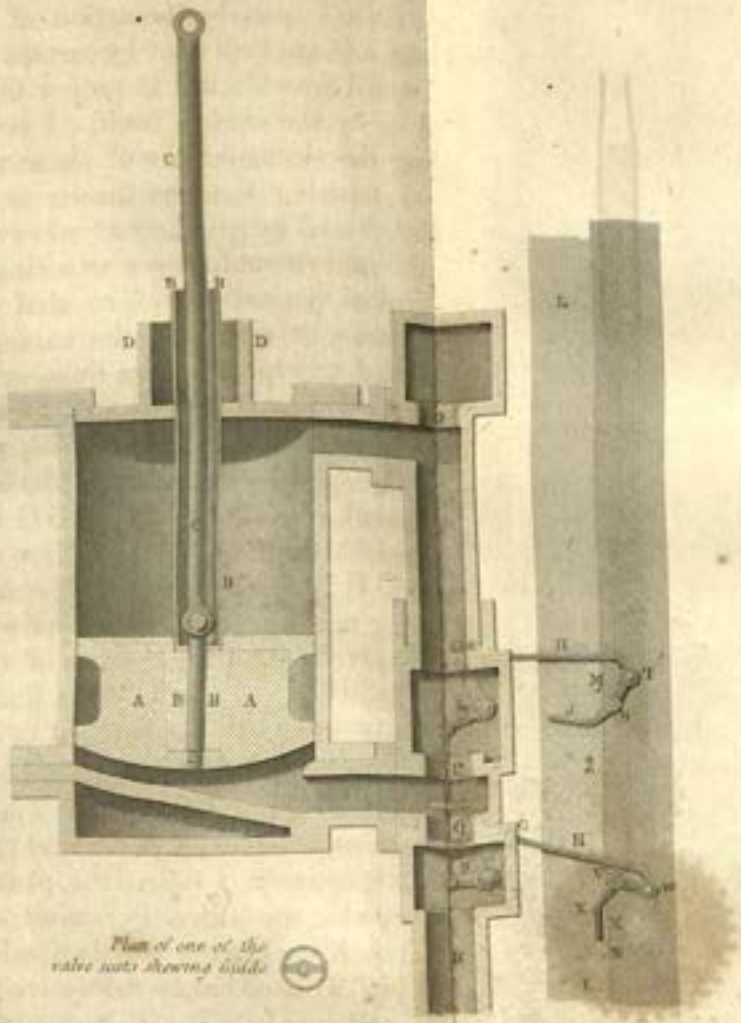
* See Plate xxvii. † See Plate xxviii, figure 19th.

Fig. 19th



John Murray, Albemarle Street, London, 1854.

Fig. 19th.



Plan of one of the valve nuts shewing Guide

Fig. 20th.

J.M.Leavy fe.

Inches 12 0 1 2 3 4 5 6 7 8 9 10 11 Feet

Inches 12 0 1 2 3 4 5 6 7 8 9 10 11 Feet

John Murray, Albemarle Street, London, 1834.

the cylinders of fire or steam engines, or which suffer it to go out of them, in such manner that they are pushed open by the action of the steam upon them, and are kept shut by certain catches or detents, which are unlocked at proper times, either by hand or by the engine itself. I perform this by making the circumference of these valves in a conical or tapering form, as shown at P and Q, figure 19th;* and by grinding or otherwise fitting exactly the said circumferences to a ring of metal which is called the valve seat, so that when shut it may be steam or air-tight: the valves Q and P are suspended or supported by links or by racks and sectors which connect them with certain levers E and F in the insides of the nozzles, which, by means of the spindles or axes on which they are fixed, communicate with the levers G G which are upon the outside of the nozzles, and are connected by the rods H H with the short levers S T and V W turning upon their respective axes S and V. When the valve is shut, the centres of the pins T and W lie a little beyond the straight lines, passing through the centres of S and G and of V and G, and no force applied at G G can unlock or discharge the valves P and Q until the points T and W are moved to the other sides of the straight lines S G and V G, respectively. When the piston of the engine descends, the valve P is shut and Q is open; the pin X strikes the handle K, which shuts Q, and the pin M immediately strikes the handle J,

* See Plate xxviii., figure 19th.

which, moving the point T from the right line, disengages the valve P, and suffers it to open. The piston A A then ascends with the plug tree L, and the pin Z returns the handle J to its proper position, which shuts P, and the pin N strikes the handle K, which permits Q to open, and the piston A A descends into its first position and commences a new stroke upward, and so continuedly. And the power and velocity of the engine is regulated by opening or shutting a regulating valve placed at O, which admits more or less steam, as required.

My Seventh new Improvement is upon steam engines which are applied to give motion to wheel carriages for removing persons or goods, or other matters, from place to place, and in which cases the engines themselves must be portable. Therefore, for the sake of lightness, I make the outside of the boiler of wood, or of thin metal, strongly secured by hoops, or otherwise, to prevent it from bursting by the strength of the steam; and the fire is contained in a vessel of metal within the boiler, and surrounded entirely by the water to be heated, except at the apertures destined to admit air to the fire, to put in the fuel, and to let out the smoke; which latter two apertures may either be situated opposite to one another in the sides of the boiler, or otherwise, as is found convenient; and the aperture to admit air to the fire may be under the boiler. The form of the boiler is not very essential, but a cylindric or globular form is best calculated to give strength. I use cylindrical steam vessels with pistons, as usual in other steam engines, and

I employ the elastic force of steam to give motion to these pistons, and after it has performed its office I discharge it into the atmosphere by a proper regulating valve, or I discharge it into a condensing vessel made air-tight and formed of thin plates or pipes of metal, having their outsides exposed to the wind, or to an artificial current of air produced by a pair of bellows, or by some similar machine wrought by the engine or by the motion of the carriage; which vessel, by cooling and condensing part of the steam, does partly exhaust the steam vessel, and thereby adds to the power of the engine, and also serves to save part of the water of which the steam was composed, and which would otherwise be lost. In some cases I apply to this use engines with two cylinders which act alternately; and in other cases I apply those engines of my invention which act forcibly both in the ascent and descent of their pistons, and by means of the rotative motion in figure 20th,* or of any other proper rotative motion, I communicate the power of these engines to the axis or axletree of one or more of the wheels of the carriage, or to another axis connected with the axletree of the carriage by means of toothed wheels; and in order to give more power to the engine when bad roads or steep ascents require it, I fix upon the axletree of the carriage two or more toothed wheels of different diameters, which when at liberty can turn round freely on the said axletree when it is at rest,

* See Plate xxviii., figure 20th.

or remain without turning when it is in motion; but, by means of catches, one of these wheels at a time can be so fixed to the axletree, that the axletree must obey the motion of the toothed wheel, which is so locked to it. And upon the primary axis, which is immediately moved by the engine, or which communicates the motion of the engine to the axletree of the carriage, I fix two or more toothed wheels of greater or lesser diameters than those on the axletree, which are moved by them respectively, so that the wheels on these two axles having their teeth always engaged in one another, the wheels on the axle of the carriage always move with the wheels on the axle of the rotative motion, but have no action to turn the wheels of the carriage except one of them be locked fast to its axletree,—then the latter receives a motion faster or slower than that of the axle of the rotative machinery, according to the respective diameter of the wheels which act upon one another. In other cases, instead of the circulating rotative machinery, I employ toothed racks or sectors of circles worked with reciprocating motions by the engines, and acting upon ratchet wheels fixed on the axles of the carriage. And I steer the carriage, or direct its motion, by altering the angle of inclination of its fore and hind wheels to one another by means of a lever or other machine. As carriages are of many sizes and variously loaded, the engines must be made powerful in proportion. But to drive a carriage containing two persons, will require an engine with a cylinder seven inches in diameter, making sixty strokes per

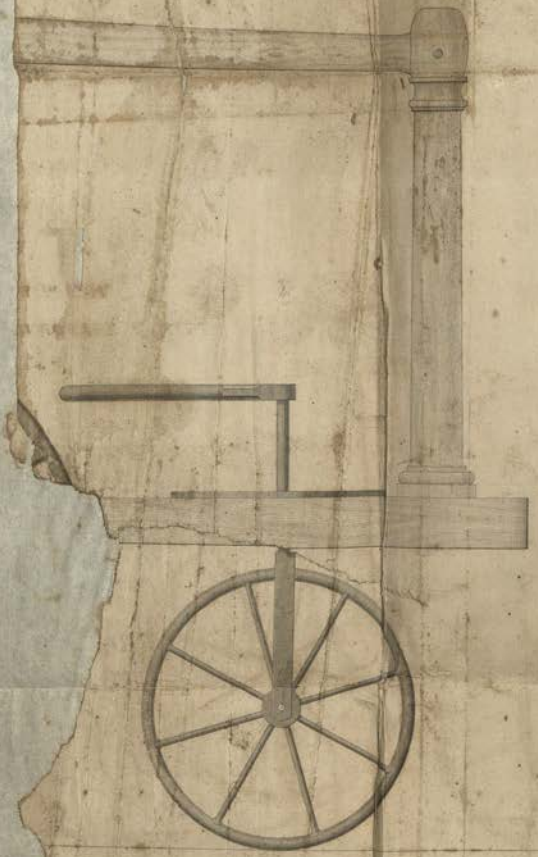
minute of one foot long each, and so constructed as to act both in the ascent and descent of the piston; and the elastic force of the steam in the boiler must occasionally be equal to the supporting a pillar of mercury thirty inches high.

LASTLY, as throughout this Specification I have particularly described my several new Improvements as applied to the improved steam engines of my invention, the sole use and property of which his present Majesty was most graciously pleased to grant to me, my executors, administrators, and assigns, by his Royal Letters Patent, bearing date the fifth day of January, in the ninth year of his reign; and which were confirmed by an Act of Parliament made and passed in the fifteenth year of his reign; and for sundry improvements on which, his Majesty was also most graciously pleased to grant to me his Royal Letters Patent, bearing dates on the twenty-fifth of October and the twelfth day of March, both in the twenty-second year of his reign;—BE IT THEREFORE REMARKED, the said new improvements herein particularly described are all, or most of them, not only applicable to the improved engines of my invention, but also to engines of other constructions which would be improved thereby; and that, as I suppose the Specifications of the several above mentioned Letters Patent to be generally known, I refer to them for an explanation of any particulars relative to my former inventions, which may not be clearly understood from these presents.

IN WITNESS whereof, I the said JAMES WATT

OMOTIVE ENGINE

ck in 1784.



J.W.Lowry sc.

don, 1854

have hereunto set my hand and seal this twenty-fourth day of August, in the year of our Lord one thousand seven hundred and eighty-four.

JAMES WATT.

Signed and sealed, being first duly stamped, in the presence of

JOHN SOUTHERN.
ZACCHEUS WALKER, junior.

Acknowledged by the within named JAMES WATT this twenty-fourth day of August, in the year of our Lord one thousand seven hundred and eighty-four, before me,

WILLIAM BEDFORD,
Master Extraordinary in Chancery.

INROLLED in His Majesty's High Court of Chancery, the twenty-fifth day of August, in the year of our Lord 1784, being first duly stamped according to the tenor of the Statutes made for that purpose.

4. P. Y. JOHN MITFORD.

SPECIFICATION OF PATENT, JUNE 14TH, 1785, FOR CERTAIN NEWLY IMPROVED METHODS OF CONSTRUCTING FURNACES OR FIRE-PLACES FOR HEATING, BOILING, OR EVAPORATING OF WATER AND OTHER LIQUIDS WHICH ARE APPLICABLE TO STEAM ENGINES AND OTHER PURPOSES, AND ALSO FOR HEATING, MELTING, AND SMELTING OF METALS AND THEIR ORES, WHEREBY GREATER EFFECTS ARE PRODUCED FROM THE FUEL, AND THE SMOKE IS IN A GREAT MEASURE PREVENTED OR CONSUMED.*

TO ALL TO WHOM these presents shall come, I, JAMES WATT, of Birmingham, in the county of Warwick, Engineer, send greeting.

WHEREAS His Most Excellent Majesty, King George the Third, by His Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the fourteenth day of June, in the twenty-fifth year of his reign, did give and grant to me, the said JAMES WATT, his especial license, full power, sole privilege, and authority, that I, the said JAMES WATT, my executors, adminis-

* Of the exact date of this invention being devised by Mr. Watt we are not aware; but in September of the same year in which he obtained his Patent for it, he mentioned that the principle on which it proceeded was "an old one of his own." (See vol. ii. p. 204, *supra*.) Until that time he does not appear ever to have tried it on a large scale: but both then and since it has, we believe, been always found to answer well in practice.

trators, and assigns, should, and lawfully might, during the term of years therein expressed, make, use, exercise, and vend throughout that part of Great Britain called England, his Dominion of Wales, and Town of Berwick upon Tweed, my invention of "CERTAIN NEWLY IMPROVED METHODS "OF CONSTRUCTING FURNACES OR FIRE-PLACES "FOR HEATING, BOILING, OR EVAPORATING OF "WATER AND OTHER LIQUIDS WHICH ARE APPLI-"CABLE TO STEAM ENGINES AND OTHER PURPOSES, "AND ALSO FOR HEATING, MELTING, AND SMELT-"ING OF METALS AND THEIR ORES, WHEREBY "GREATER EFFECTS ARE PRODUCED FROM THE "FUEL, AND THE SMOKE IS IN A GREAT MEASURE "PREVENTED OR CONSUMED;" in which said Letters Patent is contained a proviso obliging me, the said JAMES WATT, particularly to describe and ascertain the nature of my said invention, and in what manner the same is to be performed, by an instrument in writing under my hand and seal, and to cause the same to be inrolled in his Majesty's High Court of Chancery within one calendar month next and immediately after the date of the said Letters Patent, as in and by the said Letters Patent, and the statute in that behalf made, relation being thereunto respectively had, may more at large appear.

NOW KNOW YE, that in compliance with the said proviso, and in pursuance of the said statute, I, the said JAMES WATT, do hereby declare that the following is a particular description of the nature of my said invention, and in what manner

the same is to be performed (that is to say) : My said newly improved methods of constructing furnaces or fire-places consist in causing the smoke or flame of the fresh fuel, in its way to the flues or chimney, to pass together with a current of fresh air through, over, or among fuel which has already ceased to smoke, or which is converted into coke, charcoal, or cinders, and which is intensely hot, by which means the smoke and grosser parts of the flame, by coming into close contact with, or by being brought near unto the said intensely hot fuel, and by being mixed with the current of fresh or unburnt air, are consumed or converted into heat, or into pure flame free from smoke.

I put this in practice—FIRST, by stopping up every avenue or passage to the chimney or flues, except such as are left in the interstices of the fuel, by placing the fresh fuel above, or nearer to the external air, than that which is already converted into coke or charcoal; and by constructing the fire-places in such manner that the flame, and the air which animates the fire, must pass downwards, or laterally or horizontally, through the burning fuel, and pass from the lower part, or internal end or side of the fire-place, to the flues or chimney. In some cases, after the flame has passed through the burning fuel, I cause it to pass through a very hot tunnel, flue, or oven, before it comes to the bottom of the boiler, or to the part of the furnace where it is proposed to melt metal, or perform other office, by which means the smoke is still more effectually consumed. In other cases, I cause

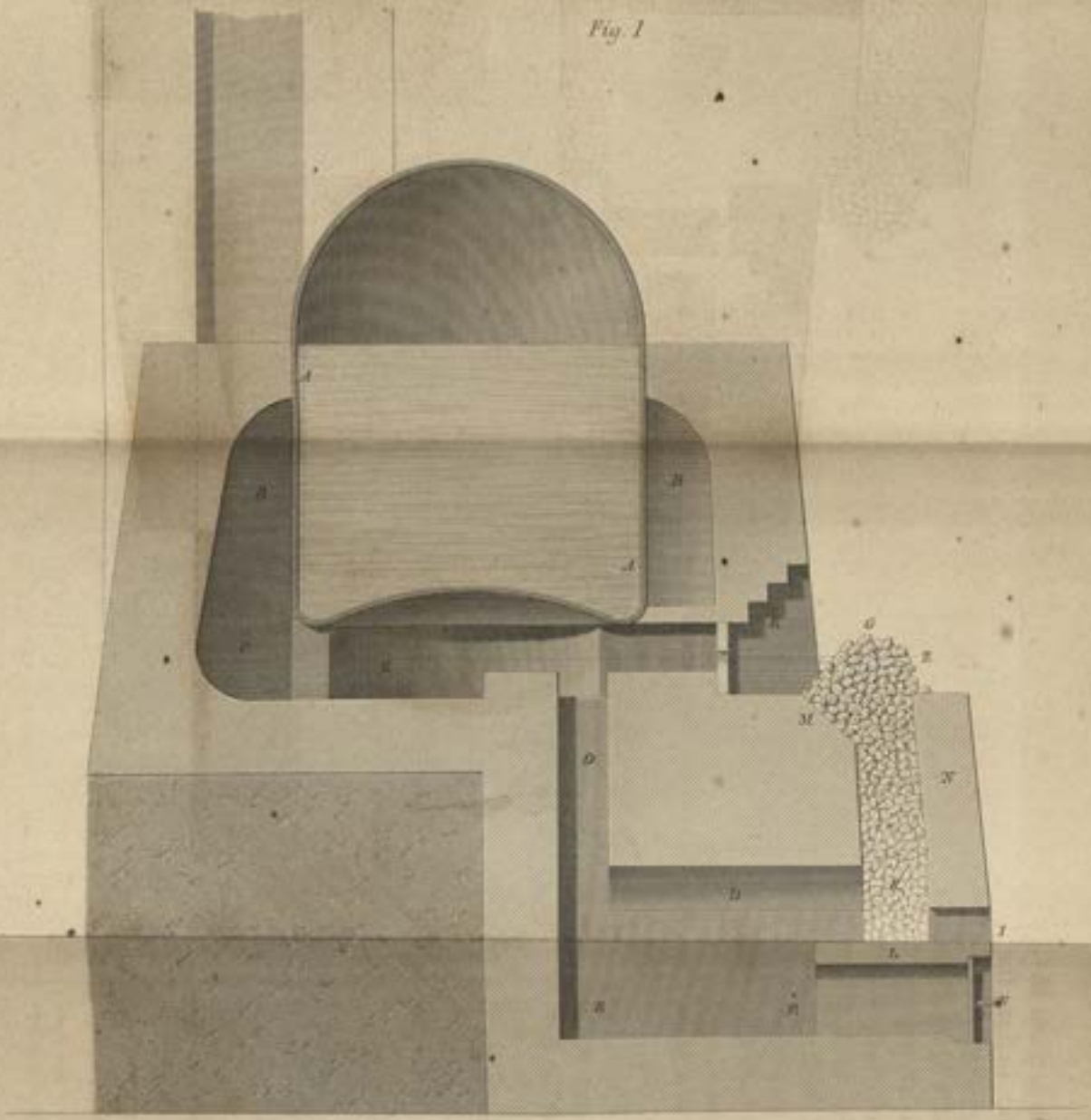
the flame to pass immediately from the fire-place into the space under a boiler, or into the bed of a melting or other furnace.

The drawing, figure 1st,* shows a section of a fire-engine boiler, and its furnace or fire-place, (which I have chosen for an example of the application of this new method to the heating and evaporating of water): A A is the boiler, which may be made of any form suitable to its use; B B is a flue surrounding the boiler, as usual; C is the up-take or passage from the space under the boiler to the flues; D D is a tunnel or flue for the flame to come from the fire-place to the boiler; E E is a place to contain the ashes; and F is a door to take them out at, (which must be kept continually shut during the time of working); G H is the fire-place: the fresh fuel is put in at G, and gradually comes down as the fuel below consumes. The part at H is very hot, being filled with cokes or coals which have ceased to smoke. J is an opening or openings to admit fresh air and regulate the fire: K is a door into the space under the boiler, which, being opened, admits air and stops the draught of the chimney, when the operation is wanted to cease. Figure 2nd † is a section of the same fire-place in the other direction, in which M M is the back of the fire-place; L, the brick arch on which the fuel lies, and E E the ash-hole. Figure 3rd ‡ is an outside view of the same fire-place, showing the air-holes

* See Plate xxx., figure 1st. † See Plate xxxi., figure 2nd.
‡ See Plate xxxi., figure 3rd.

Chimney supposed to be behind

Fig. 1



J.W.Lowry fc.

Inches 0 1 2 3 4 5 6 7 8 9 10 11 12 Feet

John Murray, Albemarle Street London 1834

Fig. 2.

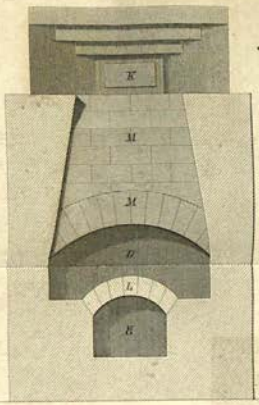


Fig. 3

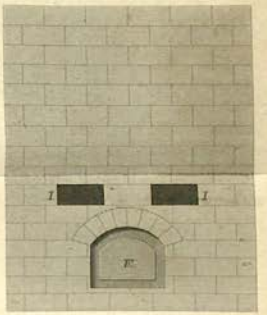
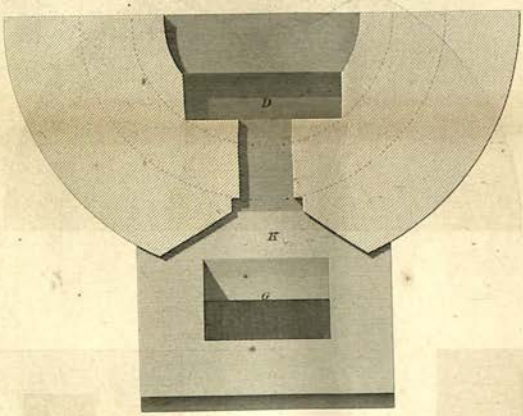


Fig. 4.



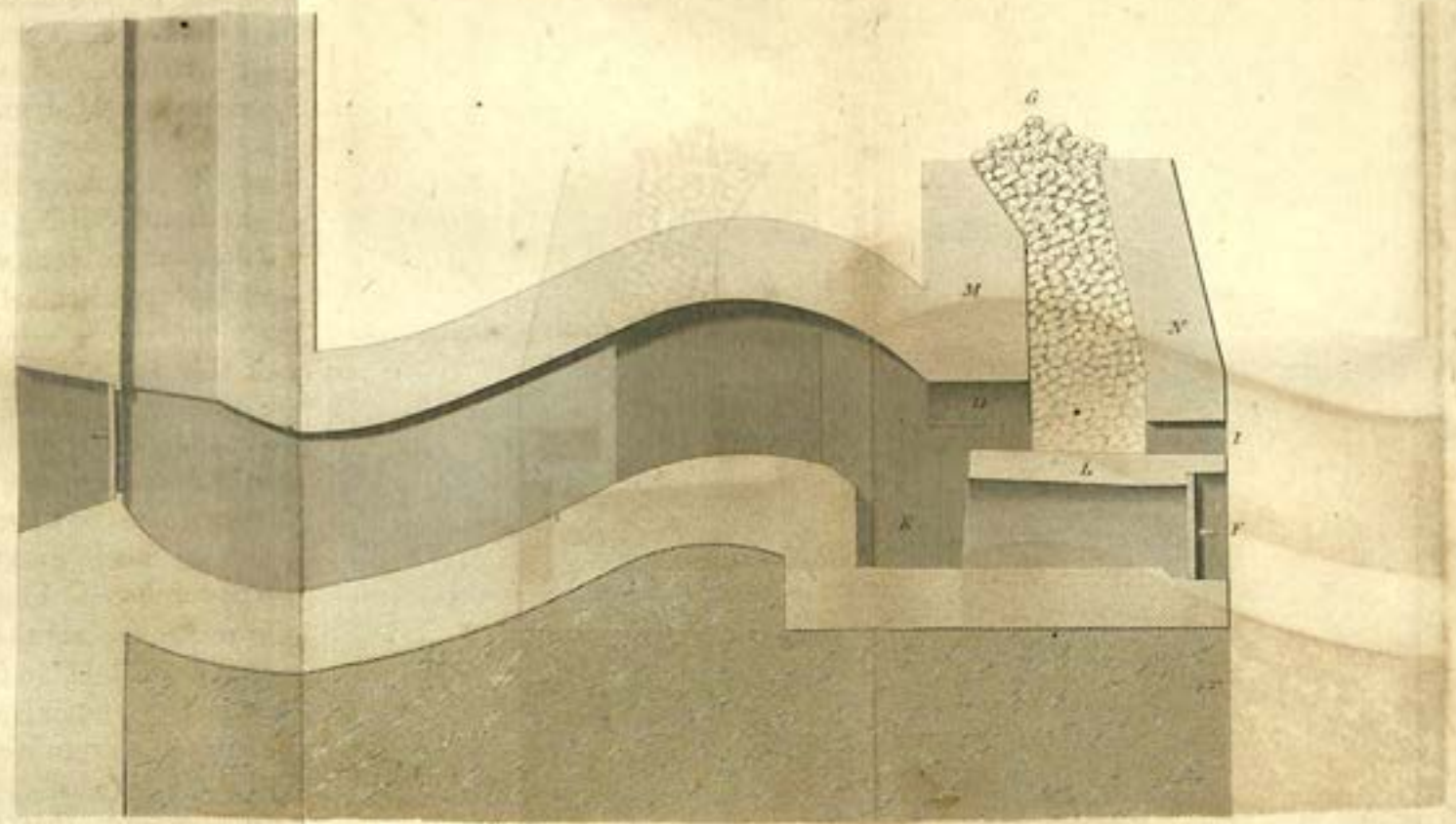
J.W.Lowry fc.

Inches 12 6 0 1 2 3 4 5 6 7 8 9 10 Feet

John Murray, Albemarle Street, London, 1854.

Chimney

Fig. 5.



J.W. Lowry sculp.

Inches 12 6 0 1 2 3 4 5 6 7 8 9 10 Feet

John Murray, Albemarle Street, London, 1854.

J J, and the ash-hole door F; and figure 4th * is a plan of the same, with part of the boiler seating, taken in the line Z Z of figure 1st. The dotted lines represent the flues, and the darts point out the direction of the flame. The fire is first kindled upon the brick arch L L, and, when well lighted, more fuel is gradually added, until it is filled up to G, and care is taken to leave proper interstices, for the air to pass either among the fuel, or between the fuel and the front wall N; and as much air is admitted at J J as can be done without causing the smoke to ascend perpendicularly from G, which it will do if too much air is admitted at J J. The dimensions of this fire-place are shown by the scale, and are properly adjusted for burning about eighty-four pounds weight of coals in an hour: where greater or less quantities are required to be burnt, the furnaces must be enlarged or diminished accordingly; or, if much greater, more furnaces than one must be employed. Figure 5th † represents this new fire-place as applied to a furnace for melting iron and other metals, and constructed without the tunnel or perpendicular flue D D in figure 1st. (N.B. The same letters refer to the same parts in all the preceding figures.) I also construct these new fire-places so that the part G H lies sloping or horizontal, and otherwise vary the figure or form and proportions of the same,—but in all cases the principle is the same; the fresh or raw fuel being placed next the external air, and so that the smoke or flame passes over or through

* See Plate xxxi., figure 4th.

† See Plate xxxii., figure 5th.

the coked or charred part of the fuel. I also occasionally cover the opening G, and cause the air to enter only or principally at J J.

SECONDLY. In some cases I place the fresh fuel on a grate as usual, as at A A, figure 6th,* and beyond that grate, at or near the place where the flame passes into the flues or chimneys, I place another smaller grate B, on which I maintain a fire of charcoal, coke, or coals which have been previously burnt until they have ceased to smoke; which, by giving intense heat and admitting some fresh air, consumes the smoke of the first fire.

LASTLY, BE IT REMEMBERED, that my said new invention consists only in the method of consuming the smoke and increasing the heat, by causing the smoke and flame of the fresh fuel to pass through very hot tunnels or pipes, or among, through, or near fuel which is intensely hot, and which has ceased to smoke, and by mixing it with fresh air when in these circumstances; and in the form and nature of the fire-places herein mentioned, described, and delineated: the boilers and other parts of the furnaces being such as are in common use.

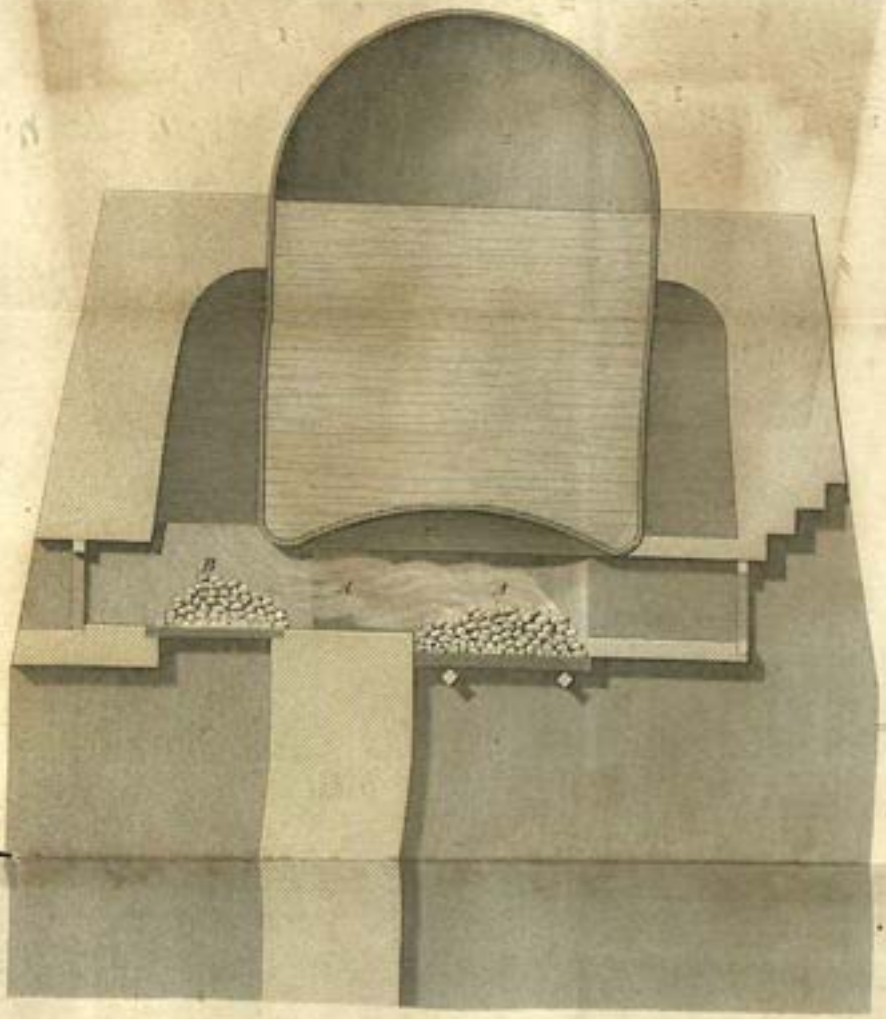
AND BE IT ALSO REMEMBERED, that these new invented fire-places are applicable to furnaces for almost every use or purpose.

IN WITNESS whereof, I have hereunto set my hand and seal this eighth day of July, in the year of our Lord one thousand seven hundred and eighty-five.

JAMES WATT.

* See Plate xxxiii., figure 6th.

Fig. 6



J.W.Lowry fculp.

Inches 0 1 2 3 4 5 6 7 8 9 10 Feet

John Murray Albemarle Street London, W.

Signed, sealed, and delivered, (being first duly stamped), and the words "which are applicable "to steam engines and other purposes," in the fifth line,—the words "together with a current of "fresh air," in the tenth line,—the words "and "by being mixed with the current of fresh or un- "burnt air," in the twelfth line,—the words "air "is," in the twenty-fifth line,—the word "ad- "mitting," in the thirty-second line,—and the words "and by mixing it with fresh air when in "these circumstances," in the thirty-fourth line,—being all previously interlined in presence of

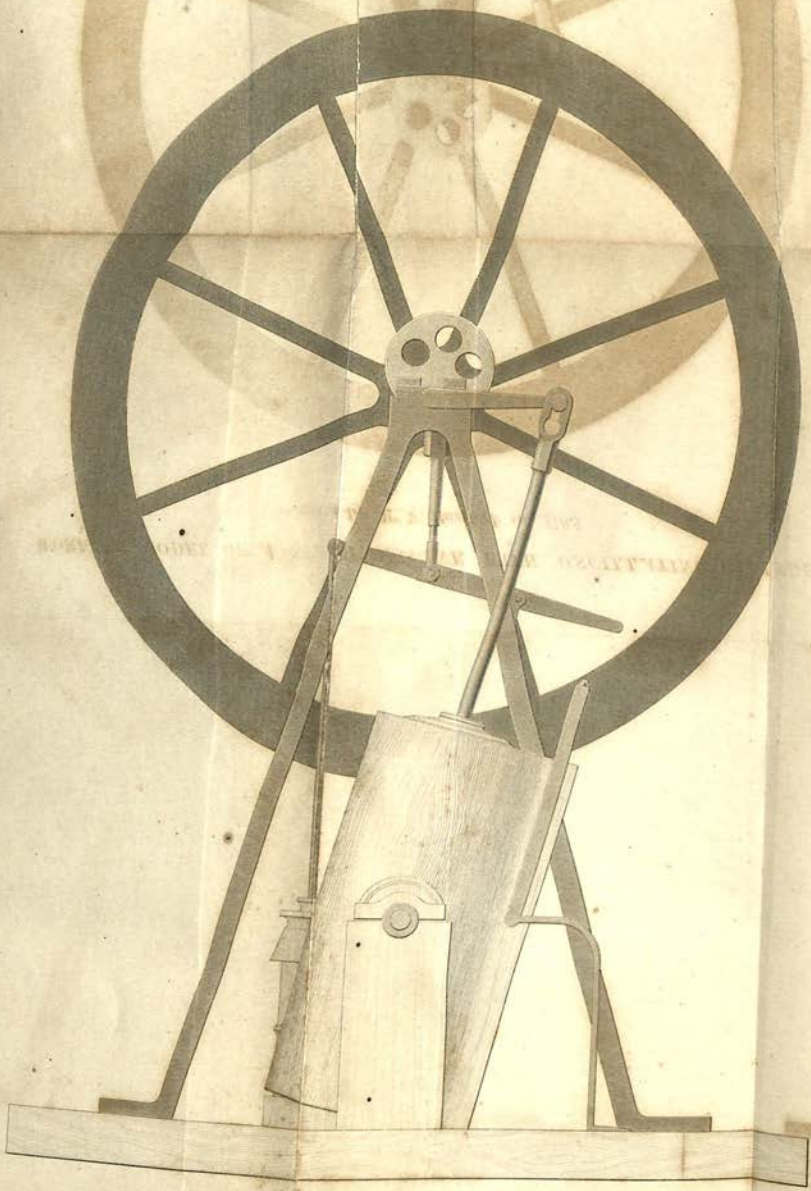
JOHN SOUTHERN.
CHARLES PORDEN.

INROLLED the ninth day of July, in the year of our Lord one thousand seven hundred and eighty-five.

END OF THE LETTERS PATENT
AND OF THE SPECIFICATIONS OF PATENTS.

WORKING MODEL OF A STEAM ENGINE WITH OSCILLATING CYLINDER.

Invented by W. Murdock in 1785.



John Murray, Albemarle Street London. 1854.

APPENDIX.

APPENDIX.

No. I.

CAPTAIN THOMAS SAVERY'S ACT, FOR THE LENGTHENING THE TERM OF A PATENT, GRANTED TO HIM, OF FOURTEEN YEARS, BEARING DATE THE 25TH OF JULY, 1698, FOR RAISING WATER AND OCCASIONING MOTION IN MILL-WORK BY FIRE; ENTITLED "AN ACT FOR THE ENCOURAGEMENT "OF A NEW INVENTION BY THOMAS SAVERY FOR RAISING "WATER AND OCCASIONING MOTION TO ALL SORTS OF "MILL-WORK BY THE IMPELLENT FORCE OF FIRE." *

WHEREAS the King's most excellent Majesty hath been graciously pleased, by his Letters Patents, bearing date the 25th day of July, anno Domini one thousand six hundred ninety and eight, under the Great Seal of England, to grant to Thomas Savery, gentleman, the sole erecting, using, teaching, exercising, and putting in practice a certain new invention (by him, the said Thomas Savery, first contrived and found out), for raising water

* This Act is here given as a very early precedent for the prolongation of the term of an exclusive privilege of a patent granted for the use of a steam-engine, which was cited and much relied on in Mr. Watt's application to Parliament in 1775; and which, although often referred to, is not readily accessible to the public. It is now printed from a transcript which was in the possession of Mr. Watt. (See Ruffhead's Statutes, where the Title is given as 10 and 11 Gul. III., cap. 31, of the Private Acts.)

and occasioning motion to all sorts of mill-work by the impellent force of fire, within the Kingdom of England, Dominion of Wales, and Town of Berwick-upon-Tweed, and all the benefits, profits, and advantages arising thereby for the space of fourteen years from the day of the date of the said Letters Patents, according to the statute in that case made and provided; And whereas the said Thomas Savery hath, by his great care, pains, and expense, since the granting the said Letters Patents, greatly improved the said invention, which is likely to be of great use and advantage to his Majesty's subjects in general, but may and probably will require many years time and much greater expense than hitherto hath been to bring the same to full perfection, and the said Thomas Savery thereby deserve [s] a better encouragement by having a longer term of years allowed him for the sole use and benefit of the said invention; Be it therefore enacted by the King's most excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and the Commons in this present Parliament assembled, and by authority of the same, that the said Thomas Savery, his executors, administrators, and assigns, by his and their deputies, servants, agents, and assistants, shall and may erect, use, teach, exercise, and put in practice the said new invention, and have and receive the benefits, profits, and advantages arising thereby not only for and during the remainder of the said term of fourteen years, in and by the said Letters Patents granted, and according to the tenor, true intent, and meaning

thereof, but also shall in like manner have and enjoy the sole use and exercise, benefits, and profits of the said invention for and during the further term of one and twenty years next after the expiration of the said term of fourteen years in and by the said Letters Patents granted as aforesaid, fully to be complete and ended in as large and ample a manner, and with like powers and authorities, to all intents and purposes, as in and by the said Letters Patents is granted, meant, mentioned, or intended; and if any person or persons, bodies politique or corporate, shall at any time or times hereafter, during the remainder of the said term of fourteen years, by the said Letters Patents granted, or during the said term of one and twenty years after the expiration of the said term of fourteen years, presume to make, imitate, use, or exercise any vessels or engines, for raising water or occasioning motion to any sort of mill-work by the impellent force of fire, he and they shall forfeit to the said Thomas Savery and his assigns all and every such vessels and engines for raising water or occasioning motion to any sorts of mill-work by the impellent force of fire, and all the pipes and utensils thereunto belonging, which shall and may be seized and taken by such means and authorities as in and by the said Letters Patents is directed and appointed.

ASHLEY COWPER,
Cler. Parliamentor.

No. II.

NOTE ON THE WORKS OF DENYS PAPIN. BY THE EDITOR.

THE prominence which, in the History of the Invention of the Steam-engine, was given to the name of Papin, by so illustrious an author as the late M. Arago, has long been matter of general notoriety. On a former occasion, during the lifetime of that great philosopher and eloquent historian of science,—(whom we had also the privilege of calling our much-honoured friend),—we felt it incumbent on us to examine, somewhat closely, how far he might have been justified in associating so closely as he has done, the respective names of Papin and of Watt. In the Notes on the Translation of the Historical Eloge of Watt, (pp. 42, 46, 47, 50-53, 56, and 57), will be found the conclusions to which our inquiries then conducted us, and which we have since seen no reason to alter, but, on the contrary, much to confirm. But we cannot help repeating the wish we then expressed, that some learned countryman of Papin would give to the world an edition of all his collected works. Some of them are now extremely scarce; and, consisting as they do, of many separate publications, and of memoirs preserved in the Transactions of various learned Societies, they are inaccessible to most readers,

and cannot be continuously examined by any one without very considerable difficulty.

It is from this circumstance alone, we firmly believe, and not from any undue national partiality, that the real claims of Papin to some of his ingenious ideas have been so long overlooked; and, from the same cause, we now quite as commonly meet with over-estimates of the degree of credit which really attaches to his experiments, unavailing in practice as many of them may have proved to be.

Not only some English writers, (as has sometimes been erroneously supposed), but some of the principal French authors also, have betrayed an entire want of acquaintance with Papin's Memoir of 1690, and with the ideas suggested in it; and have grounded their estimate of his merit as an inventor either on his well-known "*Digester*," or on the inferior sort of steam-engine which he described in 1707, or on both of those machines, but on nothing else of a more recondite or remarkable nature. Thus Belidor, in his great and valuable work published in 1739, says, "Pour dire un mot de l'origine "des Machines mûes par l'action du feu, l'on sçaura "que je n'ai trouvé personne qui prit la chose de "plus loin que M. Papin, Docteur en Médecine, "Professeur en Mathématique à Marbourg, et "Membre de la Société Royale de Londres, dans la "Préface d'un petit ouvrage, qui a pour titre: "'*Nouvelle manière d'élever l'eau par la force du feu*,' "imprimé à Cassel en 1707,"* &c. M. De Prony,

* Belidor, 'Architecture Hydraulique,' tome ii. pp. 308–310.

in 1790, after referring to the same work of Papin, says: "Nous ne parlerons pas de la machine de "Papin, qui est plus imparfaite que celle de Savery; "la grande célébrité de ses expériences sur la "vapeur est principalement fondée sur l'usage qu'il "en a fait pour dissoudre les os au moyen de son "*digesteur*, très connu sous le nom de *marmite de* "*Papin*," * &c. &c. And Bossut, in 1796, has followed a similar course; speaking first of the "marmite de Papin," as described in his work of 1682, and then of the publication which appeared, at Cassel, in 1707.† While in England, on the other hand, Stuart and Farey, in 1824 and 1827, (not to name other writers), have both done ample justice to all the contrivances of M. Papin that could be cited in connection with the history of the steam-engine.

A Dr. Ducoux, a physician at Blois, who some years ago published a pamphlet on the life and works of Papin,‡ dwells on the contents of the latter with what we cannot but term "prodigious" exaggerations; as, for example, when discussing the subject of steam-boats, he hesitates not to call Papin their "inventor," and to describe the English and American nations as a couple of thieves, who have robbed his country of her glory, and then quarrelled about the spoil! §

* De Prony, 'Architecture Hydraulique,' tome i. p. 566.

† Bossut, 'Traité d'Hydrodynamique,' tome ii. p. 475, 1796.

‡ 'Eloge Historique de Denis Papin de Blois,' &c., par le Dr. Ducoux. Blois, 1838.

§ "Les Anglais et leurs anciens colons se disputaient ainsi nos dé-"pouilles, comme ferait deux larrons qui, après avoir détroussé un

Of the ingenuity of Papin's idea of forming a vacuum by the condensation of steam, as well as of the real worthlessness in practice of his contrivance for producing it, we have repeatedly expressed our opinion;—an opinion in which we believe every well-informed and impartial mechanician of either country, without exception, will now entirely concur. But it could hardly have been supposed that a French physician would have permitted himself to utter such gross invectives against other nations, while he was himself in complete ignorance of the most ordinary works of his own countrymen on subjects such as those of which he professes to treat, and had evidently never seen the volumes,—nay, for all that we know to the contrary, had never heard of the names,—of Belidor, of De Prony, or of Bossut.

But perhaps those authors may congratulate themselves on the escape they have made, in *not* having been cited by the learned Doctor; for of those who have in that respect not been so fortunate, we observe that some have been treated with little ceremony. In his pages *Rench* stands for Wren; *Hull* for Hulls; *Edwart* for Edward; *Thurloé* and *Cromwel* for Thurloe and Cromwell. The consonant which he has very unnecessarily abstracted from "*Fitzgeral*," he thrice also, unkindly, denies to "*M. Tregold.*" Mr. Robert Stuart, the nominal author of a 'History of the 'Steam Engine,' 1824, as well as of the amusing

"voyageur, le laisseraient à l'écart pour se partager son butin."—*Ibid.* p. 61.

'Anecdotes of Steam Engines,' 1829, would, we imagine, be puzzled to recognise himself under the title of *Sir Robert Stuart*; still more so, under that of *Sir Stuart*. And of the orthography of the name of "*docteur Hoock*," we cannot say less, than that it reflects little credit on the accuracy which has superintended the preparation of the *boock* thus set forth by "*docteur Ducoock*."

Dr. Ducoux speaks of the English nation as "nos antagonistes d'outre-mer;" an expression which, as he appears to have been a navy and army surgeon, we fear must be held to indicate some rather uncomfortable associations still lurking in his mind. We shall not, however, on this occasion pretend to rival him in his national animosities; nor to depreciate, on account of his trivial indiscretions, the real greatness of his countrymen in science, in arts, and in arms. We rather hail with cordiality the alliance which now unites the two powerful nations whom Nature has made such near neighbours, and who ought to be mutual friends; and we turn with great satisfaction to the work of another French author, which gained a prize proposed by the Imperial Academy of St. Petersburg, and in which it is said (speaking of the same idea of Papin), "Il paroît qu'un de ceux "à qui l'on en doit la première idée est Papin, "Médecin François, Professeur de Physique Expé- "rimentale à Marbourg, et Membre de la Société "Royale de Londres : car outre que par la fameuse "expérience de sa marmite, il a fait connoître la "force de la vapeur, il propose, dans un petit

" ouvrage imprimé en 1695, la construction d'une " nouvelle pompe dont les pistons seront mis en " mouvement par la vapeur de l'eau bouillante;" but it is added, with equal justice and modesty, " C'étoit déjà beaucoup que de proposer cette " idée; mais il falloit la réaliser et la mettre en " pratique d'une manière simple et commode. " *Les Anglois sont les premiers qui y soient par-* " *venus.*" *

Regarding one of the works of Papin,—viz. his 'Recueil de diverses pièces touchant quelques 'Nouvelles Machines,'— Ducoux, writing in 1838, tells the following story:—" Le seul exemplaire " que possédait la Bibliothèque Royale de Paris, a " été tout récemment *soustrait par un lecteur*, que le " bibliothécaire a cru pouvoir me désigner comme " *étant Anglais.* Ce riche cabinet le tenait, je " crois, de M. Molard, membre de l'Académie des " Sciences, qui, en 1830, dans tout Paris, en était " le seul possesseur," &c. &c. We can readily pardon our countrymen if they are led, by the mode in which this tale is told, (but which we are far from wishing " pouvoir désigner comme " étant *vraiment Français*"), to entertain very considerable doubts as to its accuracy. Possibly the volume in question, like so many more of which the " perte " was long so vehemently,—and, as the event showed, so unjustly,—laid upon the " bibliothecaire " of that great library himself, may

* 'Théorie des Machines mûes par la force de la Vapeur de l'Eau. 'Par M. De Maillard, Capitaine-Lieutenant au Corps Impérial et 'Royal du Génie.' 1784; pp. 8–10.

ere now have reappeared on its shelves, and be discovered never to have quitted them. (See the 'Affaire Libri;' one set of the various pamphlets, &c., published in regard to which, in 1849 and the two succeeding years alone, forms no fewer than twelve thick octavo volumes.) If, however, this hope should unfortunately be disappointed, it is plain that if the "bibliothécaire" was in possession of evidence sufficient to warrant his making such a statement, it was his unquestionable duty to have prosecuted the "soustraiteur" as a thief. If otherwise, Dr. Ducoux should have paused, before placing himself in the position in which he now stands, of uttering a serious and unsupported accusation, of so odious a nature, against an anonymous culprit; which is, besides, not free from the taint of a suspicion that it may have been dictated by illiberal national aversion. At all events, every "*lecteur Anglais*" may thoroughly disregard, as unworthy of further notice, a charge of such a kind, thus vaguely uttered, without any of those specific particulars which would have been requisite in order to establish it, and therefore,—as we think,—to justify its author in making it.

In his 'Notice Scientifique sur les Machines à 'Vapeur,' in the 'Annuaire du Bureau des Longi-'tudes' for 1830, M. Arago repeatedly cites and gives extracts from the 'Recueil;' but he has not mentioned whether the copy with which he was familiar was that stated by Ducoux to have belonged to M. Molard, or whether Paris could then boast of a duplicate. M. Hachette, however, in

his 'Histoire des Machines à Vapeur, depuis leur 'origine jusqu'à nos jours,' published in March of the same year in which M. Arago wrote, says, "On ne connoît à Paris qu'un seul exem- "plaire de cet ouvrage, qui appartient à M. "Molard, membre de l'Académie de Sciences;" (p. 55, *note*). This circumstance, especially when coupled with Ducoux's story of the subsequent fate of that copy, is certainly a curious verification of the remark which we observe in the 'Acta Eru- 'ditorum, "At cum *opuscula ejusmodi facile deperdi* "*rariusque de novo imprimi soleant*;" and adds force to our repeated request for a complete edition of all Papin's works, prepared by some competent person.

As, however, it appears doubtful whether we can hope ever to see even a single copy of either of the two editions of the 'Recueil,'—of the French one, *i. e.*, of Cassel, or of the Latin one of Marburg, both of 1695,—it is satisfactory to know that contemporary accounts of the contents of that work are preserved in the 'Acta Eruditorum' for 1695, pp. 376–382, and in the 'Philosophical Transactions' for 1697, p. 483. It thence appears that the 'Recueil,' or 'Fasciculus,' was made up of the following separate papers or memoirs:—

1. On the Hessian Pump.

2. On several ways of saving fuel, "chiefly by "a contrivance to burn the smoak, by causing a "draught of air to come or be forced down the "tunnel of the chimney to the fireplace."

3. On "several inventions to draw water out of

" mines by means of some river not far distant " from them, and this is performed by the pressure " of the air to cylindrical vessels, being alternately " evacuated."

4. The paper of 1690, here reprinted; (see pp. 139-154, *infra*.) " The fourth Letter shows a " method of draining mines where you have not the " conveniency of a near river to play the aforesaid " engine," [that, viz., for drawing the water out of mines by means of a neighbouring river, and the pressure of the air on cylindrical vessels alternately evacuated]; " where, having touched upon the in- " conveniency of making a vacuum in the cylinder " for this purpose with gunpowder, he proposes " the alternately turning a small surface of water " into vapour, by fire applied to the bottom of the " cylinder that contains it, which vapour forces up " the plug in the cylinder to a considerable height, " and which, (as the vapour condenses, as the water " cools when taken from the fire), descends again " by the air's pressure, and is applied to raise the " water out of the mine."

5. Dispute between Mr. Dominique Gulielmini and Mr. Papin concerning running waters.

6. Abridgment of a dispute between himself and the same person concerning the true estimate of powers or moving forces.

7. On instruments proper to conserve flame under water.

8. A description of the diving-bell, or " navis " urinatoria," of Prince Charles, Landgrave of Hesse. (This article is mentioned only in the

'Acta Eruditorum,' and omitted in the 'Philoso-'phical Transactions;' from which it may perhaps be concluded that it is contained in the 'Fasci-'culus' published at Marburg, but not in the 'Recueil' published at Cassel, of which the former is analysed in the 'Acta,' and the latter in the 'Phil. Trans.')

And, lastly, "The whole treatise concludes "[with] an harangue, which the author made "when he was admitted professor of mathematics "at Marburgh."

From this analysis it appears tolerably certain, that the work about which so much has been said contained in reality nothing on the subject of steam or a steam-engine, excepting the memoir of 1690, first published in the 'Acta Eruditorum' for that year, and now reprinted in these pages; and that even the loss of every copy of the 'Re-'cueil,' or 'Fasciculus,' would therefore not have the effect either of invalidating any claims which M. Papin has to be considered an inventor on those subjects, or of diminishing the force of the evidence by which they are supported. He undoubtedly appears to have been a person who displayed very considerable ingenuity on those matters of physical inquiry to which his attention was directed; and if, in the history of the steam-engine, justice was for a time measured out to his name and works with rather a sparing hand, we must confess that in later times that deficiency has been *at least* compensated, by the strenuous, and indeed somewhat exuberant exertions of his countrymen!

In the meantime, both as an act of justice to the memory of the *ci-devant* Secretary to the Royal Society, and for the convenient reference of our readers, we venture to reprint at full length the paper published by Papin in the Acta Eruditorum Lipsiae for 1690, on which his claims to be considered one of the early inventors of the steam-engine, so eagerly urged by his countrymen, principally depend, and which is, at all events, an interesting record of very considerable ingenuity on his part. That all may have it in their power to judge for themselves how far it does or does not justify the somewhat extravagant conclusions which have sometimes been deduced from it, we subjoin a translation, in which we have endeavoured to convey very literally the sense of the original; together with a fac-simile engraving on wood of the figure, with letters of reference, by which the paper in the Leipzig Transactions is accompanied.

As some little further contribution towards the project we have commended to the attention of some learned native of the country which claims Papin as a son, we also annex a list of his various works, in so far as known to us.* Without professing to guarantee its absolute completeness, we can at least venture to aver that it is much more perfect than the meagre one furnished by Ducoux; which indeed is deficient in by far the greater number of the items, and erroneous as to some of the rest.

* See p. 155, *infra*.

No. III.

DION. PAPINI.

NOVA METHODUS AD VIRES MOTRICES VALIDISSIMAS LEVI PRETIO COMPARANDAS.*

IN machinâ pro novo pulveris pyrii usu, quæ in *Actis Erud.* anni 1688, mens. Septemb. descripta est, hoc in primis desiderabatur, ut pulvis pyrius in infimâ parte tubi A A accensus totam cavitatem flamma ita repleret, ut aër inde penitus expelleretur, tubusque infra pistillum B B aëre prorsus vacuus remaneret: ibi vero dictum est, quod effectus voto non satis respondere potuerit, sed non obstantibus omnibus cautelis ibidem me-

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A NEW METHOD OF OBTAINING VERY GREAT MOVING POWERS AT SMALL COST. BY DENYS PAPIN.

IN the machine for a new use of gunpowder, which is described in the 'Acta Eruditorum' for the month of September, 1688, the first desideratum was, that the gunpowder fired in the bottom of the tube A A should fill the whole cavity with flame, so that the air might be entirely expelled from it, and the tube remain a perfect vacuum beneath the piston B B. But there it was mentioned, that the desired effect could not be sufficiently attained; but that, notwithstanding all the

* Reprinted from the 'Acta Eruditorum Lipsiæ' for 1690, pp. 410-414.

moratis, semper tamen remanserit in tubo quinta circiter pars aëris, qui in eo contineri solet. Unde duplex oritur incommodum; 1. Quod dimidiâ parte optati effectus hoc modo frustremur; ita ut 150 duntaxat librarum pondus ad altitudinem unius pedis elevari possit, quum alioquin 300 librae debuissent attolli, si tubus A A fuisset perfecte evacuatus: alterum incommodum hoc est, quod pistillo descendente gradatim minuatur vis ipsum deprimens, prout ibidem observatum est; unde requiritur ut artificio aliquo prospiciamus, ut decrescente sic vi motrice, resistentia itidem minuatur, quo possit usque ad finem a dicta vi motrice superari; quemadmodum in horologiis

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precautions there specified, there always remained in the tube about a fifth part of the air usually contained in it. Whence a twofold inconvenience arises: viz. 1st, that in this way we lose half of the desired effect, so that scarcely can 150 lbs. weight be raised to the height of one foot, when otherwise 300 lbs. ought to have been raised, if the tube A A had been perfectly emptied; and 2ndly, that as the piston gradually descends, the force which makes it descend is itself diminished, as was also observed in the passage already referred to, so that we have to provide, by some contrivance, that, as the moving force thus decreases, the resistance may in like manner decrease, so that it may be overcome by the aforesaid moving force until the end: just as in watches the unequal

portatilibus vis inaequalis laminae elasticae totam machinam moventis certâ arte ita temperatur, ut per totum decursum æquali facilitate rotarum resistentiam vincat: longe vero commodius foret, si vis movens a principio usque ad finem semper remaneret æqualis. Nonnulla igitur in hunc finem jam pridem tentata sunt, quo posset vacuum, pulveris pyrii ope, perfectum obtineri; sic enim, nullo aëre infra pistillum resistente, tota atmosphæræ columna super incumbens dictum pistillum æquali vi usque ad fundum deprimeret. Sed frustra hactenus huic negotio insudatum est, semperque quinta circiter pars aëris in tubo A A

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force of the main-spring, which moves the whole machine, is so regulated by art, that through the whole of its running down it overcomes the resistance of the wheels with equal ease. But it would be far more convenient if the moving force were to remain always the same, from the beginning to the end. Some attempts have, therefore, already been made to ascertain how a perfect vacuum could be obtained by the help of gunpowder; for in this way, were there no air to offer resistance beneath the piston, the whole column of the atmosphere pressing upon the said piston would press it with an equable force down to the bottom. But hitherto such attempts have been in vain; and always, after the flame of the gunpowder is extinguished, about a fifth part of the air remains in the tube A A.

relinquitur post extinctam pulveris pyrii flammam. Aliâ igitur viâ finem eundem assequi conatus sum: quumque ea sit aquæ proprietas, ut exigua ipsius quantitas vi caloris in vapores conversa vim habeat elasticam instar aëris, superveniente autem frigore in aquam iterum ità resolvatur, ut nullum dictæ vis elasticæ vestigium remaneat: facile credidi, construi posse machinas, in quibus aqua mediante calore non valde intenso, levibusque sumptibus, perfectum illud vacuum efficeret, quod pulveris pyrii ope nequaquam poterat obtineri: inter varias autem constructiones, quæ in hunc finem fingi possunt, hæc mihi aptissima visa est.

A A est tubus æqualis ubique amplitudinis, in

By another way, therefore, I endeavoured to attain the same end; and, since it is a property of water that a small quantity of it, converted into steam by the force of heat, has an elastic force like that of the air, but, when cold supervenes, is again resolved into water, so that no trace of the said elastic force remains; I felt confident that machines might be constructed wherein water, by means of no very intense heat, and at small cost, might produce that perfect vacuum which had failed to be obtained by aid of gunpowder. But of the various constructions which can be contrived for this purpose, the following seemed to me to be the most suitable.

A A is a tube of uniform diameter throughout,

inferiori parte exacte clausus : B B est pistillum huic tubo aptatum : D D manubrium pistillo affixum : E E virga ferrea circa axem in F mobilis : G lamina elastica virgam ferream E E ita premens, ut dicta virga in hiatum H necessario intrudatur, statim atque pistillum cum manubrio ad eam altitudinem perductum est, ut dictus hiatus H supra operculum I I emineat : L est foraminulum in pistillo, per quod potest aër ex fundo tubi A A egredi, quum primum pistillum in dictum intruditur. Hujus instrumenti usus hic est ; infunditur tubo A A exigua aquæ quantitas ad 3 vel 4 linearum altitudinem ; tum immittitur pistillum et ad fundum usque impellitur, donec pars aquæ prius immissæ per foramen L regurgitet ; tum obturatur

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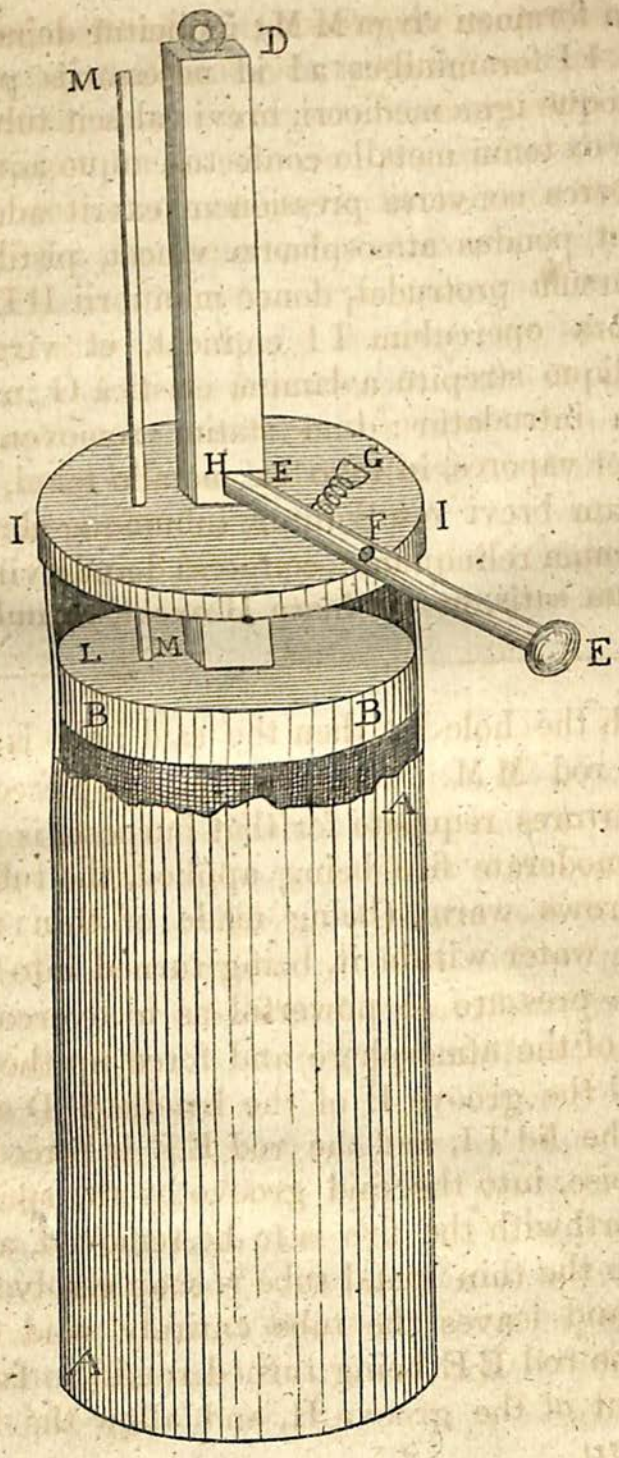
close shut at the bottom ; B B is a piston fitted to the tube ; D D a handle fixed to the piston ; E E an iron rod moveable round an axis in F ; G a spring, pressing the cross rod E E, so that the said rod must be forced into the groove H as soon as the piston with the handle has arrived at such a height as that the said groove H appears above the lid I I ; L is a little hole in the piston, through which the air can escape from the bottom of the tube A A, when first the piston is forced into it. The use of this instrument is as follows : A small quantity of water is poured into the tube A A, to the depth of 3 or 4 lines ; then the piston is inserted, and forced down to the bottom, till a portion of the water previously poured in comes


D
M
H
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G
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A

dictum foramen virga M M; inducitur deinde operculum I I foraminibus ad id necessariis pervium, admotoque igne mediocri, brevi calescit tubus A A, utpote ex tenui metallo confectus, atque aqua intus in vapores conversâ pressionem exerit adeo validam, ut pondus atmosphæræ vincat, pistillumque B B sursum protrudat, donec manubrii D D hiatus H supra operculum I I emineat, et virga E E cum aliquo strepitu a laminâ elasticâ G in dictum hiatum intrudatur: tum statim removendus est ignis, et vapores, in tubo ex metallo tenui, frigore in aquam brevi resolvuntur, tubumque aëre prorsus vacuum relinquunt; conversâ deinde virgâ E E quantum satis, ut ex hiatu H exeat, manubrioque

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through the hole L; then the said hole is closed by the rod M M. Next the lid I I, pierced with the apertures requisite for that purpose, is put on, and a moderate fire being applied, the tube A A soon grows warm, (being made of thin metal), and the water within it, being turned into steam, exerts a pressure so powerful as to overcome the weight of the atmosphere and force up the piston B B, till the groove H of the handle D D appears above the lid I I, and the rod E E is forced, with some noise, into the said groove by the spring G. Then forthwith the fire is to be removed, and the steam in the thin metal tube is soon resolved into water, and leaves the tube entirely void of air. Next, the rod E E being turned round so far as to come out of the groove H, and allow the handle

DD descensum permittat: statim deprimitur pistillum B B totius atmosphæræ pondere, motumque intentum causatur eo majore efficacia, quo major est tubi amplitudo. Neque dubitandum est, quin totum atmosphæræ pondus suas in tubis sic comparatis vires exerat: experientia enim comprobavi, pistillum ad summitatem usque tubi vi caloris elevatum, paulo post ad fundum usque iterum descendere, idque vicibus sæpius repetitis, adeo ut nulla aëris infra prementis suspicio oriri queat: meus autem tubus cujus diameter $2\frac{1}{2}$ digitos non excedit, sexaginta tamen libras in altum evehit eadem velocitate, quâ pistillum in tubum deprimitur; et tubus ipse vix quinque uncias æquipon-

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D D to descend, the piston B B is forthwith pressed down by the whole weight of the atmosphere, and causes the intended movement, which is of an energy great in proportion to the size of the tube. Nor is it to be doubted that the whole weight of the atmosphere exerts its force in tubes so constructed; for I have established by experiment, that a piston, raised to the top of the tube by the force of heat, shortly afterwards descends again to the bottom, and so on alternately for a number of times, so that no suspicion can arise of air pressing beneath. Now my tube, the diameter of which does not exceed $2\frac{1}{2}$ inches, yet raises sixty lbs. aloft with the same velocity as the piston is forced down into the tube, and the tube itself scarcely weighs five ounces.

derat. Vix igitur dubito quin confici possint tubi, quorum singulorum pondus vix 40 libras æquaret, et tamen bis mille libras singulis operationibus ad altitudinem 4 pedum possent attollere. Expertus sum præterea, quod tempus unius minuti sufficiat, ut ignis mediocris pistillum in meo tubo ad summitatem usque propellat: quam autem ignis debeat esse proportionatus amplitudini tuborum, ingentes æque cito ferme ac exigui tubi calefieri possent: unde patet, quam immanes vires motrices hujus simplicissimi artificii ope obtineri queant, quamque levi pretio. Notum enim est, columnam aëris incumbentem tubo cujus diameter est unius pedis, æqui ponderare ferme bis mille libras; si vero diameter sit duorum pedum, fere pondus fore octies

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I therefore have little doubt but that tubes may be manufactured, the weight of each of which would scarcely amount to 40 lbs., and yet which could raise, at each operation, two thousand lbs. to a height of four feet. Moreover, I ascertained that one minute's time is sufficient for a moderate fire to drive the piston in my tube up to the top; but, as the fire ought to be proportionate to the size of the tubes, large tubes could be heated almost as soon as small ones: whence it is clear what vast moving powers may be obtained by help of this most simple contrivance, and at how small a cost. For it is known that the column of air pressing on a tube whose diameter is a foot, counterbalances nearly two thousand lbs.; but

mille librarum, et sic in cæteris pressionem augeri in ratione triplicatâ diametrorum; hinc sequitur, quod ignis in fornace cujus diameter duos pedes tantisper excederet, posset sufficere ad 8000 libras singulis minutis elevandas ad altitudinem 4 pedum, si tubi tantæ altitudini pararentur: ignis enim in fornace ex tenui ferro confecta posset ab uno tubo ad alium facile moveri, atque ita idem ignis continue in hoc vel illo tubo efficacissimum illud vacuum pararet. Si quis jam attendere velit ad magnitudinem virium hac ratione obtinendarum, et ad exiguos sumptus ad comparandam sufficientem ligni quantitatem requisitos: fatebitur procul dubio nostram hanc methodum usui pul-

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if the diameter be two feet, the weight would be nearly eight thousand lbs.; and that, in other dimensions, the pressure increases in like manner in the triplicate ratio of the diameters. Hence it follows, that the fire in a grate whose diameter scarcely exceeds two feet, might suffice to raise 8000 lbs. each minute to a height of 4 feet, if tubes were provided of such a height; for a fire might be made in a grate of thin iron, to be easily moved from one tube to another, and so the same fire might continually be preparing that most efficacious vacuum in one tube or another.

If any one now will consider the magnitude of the forces to be obtained in this way, and the trifling expense at which a sufficient quantity of fuel can be procured, he will certainly admit that

veris pyrii, de quo supra dictum est, longe esse anteponendam, quum præsertim vacuum hac ratione perfectum obtineatur, atque ita amoveantur incommoda superius recensita.

Quomodo jam vis illa ad extrahendam ex fodinis aquam aut mineram, ferreos globos ad maximam distantiam projiciendos, naves adverso vento provehendas, atque ad alios ejusmodi usus quam plurimos applicari queat, longum nimis foret hic recensere: verum unusquisque, pro datâ occasione, machinarum fabricam excogitare debet proposito suo accommodatam. Hic tamen obiter annotabo, quot nominibus ad naves in mari movendas ejusmodi vis vulgaribus remigibus anteponenda foret: 1, enim, vulgares remiges pondere suo

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this my method is far preferable to the use of gunpowder above spoken of, especially as in this way a perfect vacuum is obtained, and so the inconveniences above recounted are avoided.

In what manner that power can be applied to draw water or ore from mines, to discharge iron bullets to a great distance, to propel ships against the wind, and to a multitude of other similar purposes, it would be too long here to detail; but each individual, according to the particular occasion, must select the construction of machinery appropriate to his purpose. Here, however, I will in passing remark, how greatly such a power is to be preferred to common rowers for moving vessels in the sea; for, 1st, the weight

triremem prægravant, ineptioremque ad motum reddunt: 2, multum loci requirunt, atque ita magno sunt in navi impedimento: 3, non semper datur tot ejusmodi homines reperire, quot necessitas postulat: 4, denique remigibus sive in alto desudent, sive in portu quiescant, necessarium semper alimentum est suppeditandum, quo sumptus non parum augentur. Nostri vero tubi exiguo admodum pondere navem retardarent, ut supra dictum; exiguum quoque locum occuparent; possent etiam in sufficienti quantitate facile comparari, si semel opificium in hunc finem extructum et instructum foret: ac denique pro dictis tubis nullum nisi operationis tempore lignum con-

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of the common rowers loads the vessel, and retards its progress; 2dly, they require much room, and so are a great hindrance in the ship; 3dly, it is not always possible to find the requisite number of men; 4thly and lastly, the rowers, whether they are toiling on the deep, or resting in harbour, must always be supplied with needful food, whereby the expenses are greatly increased. But my tubes would, as has been already observed, have a very small weight to retard the ship; would also take up little room; might also be readily prepared in sufficient numbers, if once a manufactory were built and fitted up for that purpose; and, lastly, no fuel would be consumed for the said tubes, excepting at the time of the operation; while in harbour they would require no expenditure.

sumeretur; in portu autem nullos sumptus requirerent. Quoniam autem remi vulgares minus commode ab ejusmodi tubis moveri possent, adhibendi forent remi rotatiles, quales memini me vidisse in machinâ, Serenissimi Principis Ruperti Palatini jussu, Londini constructâ, quæ ab equis remorum ejusmodi ope in motum agebatur, quaeque cymbam regiam sedecim remigibus instructam longo post se intervallo relinquebat: sic, procul dubio, remi axi alicui infixi commodissime circumagi possent a tubis nostris, si nimirum manubria pistillorum dentibus instruerentur, qui rotulas itidem dentatas axi remorum affixas necessario circumverterent: necesse foret duntaxat, ut tres vel quatuor tubi eidem axi applicarentur, quo

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But since common oars could not easily be moved by such tubes, paddle-wheels would have to be employed, such as I remember having seen in a machine constructed at London by command of the Most Serene Rupert Prince Palatine, which was put in motion by horses, by aid of oars of that sort, and which left a long way behind it the Royal barge manned by sixteen rowers. So, no doubt, oars fixed into an axis could be most conveniently driven round by my tubes, by having the rods of the pistons fitted with teeth, which would force round small wheels, toothed in like manner, fastened to the axis of the paddles. It would only be requisite that three or four tubes should be applied to the same axis, by which

posset ipsius motus sine interruptione continuari: dum enim pistillum aliquod ad fundum tubi sui pertingeret, adeo ut non posset amplius axem circumagere, antequam ad tubi summitatem vi vaporum iterum propelleretur: posset statim amoveri retinaculum pistilli alii, cujus descendendo vis ejusdem axis motum continuaret: et sic deinceps aliud adhuc pistillum deprimeretur, vimque suam in eundem axem exereret, interea dum pistilla prius depressa vi caloris ad summitatem iterum elevarentur, sicque novam movendi dicti axis vim acquirerent, modo superius descripto: unica autem fornax mediocri igne instructa ad omnia illa pistilla successive elevanda sufficeret. Verum objiciet

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means its motion could be continued without interruption; for while any one piston might be touching the bottom of its tube, so that it could drive the axis round no further, before being again propelled by the force of the steam to the top of the tube, the bolt of another piston could immediately be removed, the force of which in its descent would continue the motion of the axis; and so again yet another piston could be lowered, and exert its force on the same axis, while the pistons first pressed down were again being raised to the top by the force of heat, and so were gaining new force to move the said axis, in the manner above described. But one grate, containing a moderate fire, would be sufficient to raise all of those pistons in succession.

forsan aliquis, dentes manubriorum impactos dentibus rotarum ascendendo et descendendo debere motus oppositos axi nostro impertiri, atque ita pistilla ascendentia descendentium, aut descendentia ascendentium motum impeditura esse. Levissima vero est hæc objectio; notissimum enim est apud automatopoeos artificium, quo rotulæ dentatæ axi ita affiguntur, ut versus unam partem circumactæ axem necessario secum ducant; at versus alteram partem circumeuntes nullum eidem axi motum impertiantur, sed illum motu opposito liberrime circumverti permittant. Præcipua igitur difficultas consistit in obtinendo opificio illo ad

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But perhaps some one may object, that the teeth of the piston-rods, fitting into the teeth of the wheels, must in their ascent and descent communicate opposite movements to my axis; and that so the ascending pistons would hinder the movement of the descending ones, and the descending pistons would hinder that of the ascending ones. But this objection is a very trifling one; for machine-makers are well acquainted with a method whereby toothed wheels are so fixed to an axis, that when moved round in one direction they carry the axis round with them, but when going round in the other direction they communicate no movement to the same axis, but allow it to be very freely turned round with an opposite movement. The principal difficulty, therefore, consists in finding the manufactory for easily

prægrandes tubos facili negotio confingendos, prout in *Actis Erud. A.* 1688, *Mens. Sept.* fusius dictum est: atque ad illud procurandum nova hæc machina non leve debet incitamentum superaddere, quippe quæ demonstrat luculentius, tales tubos prægrandes ad plurimos insignes usus commodissime posse adhiberi.

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making very large tubes, as I have more fully stated in the *Acta Eruditorum* for September, 1688. And for preparing that, this new machine ought to supply no small additional inducement, inasmuch as it very clearly shows that such very large tubes can be most advantageously employed for several important purposes.

No. IV.

LIST OF THE WORKS OF DENYS PAPIN.

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1. *Separate Substantive Publications.*

1. Nouvelles experiences du vuide, avec la description des machines qui servent à les faire. 4to. Paris, 1674. (Dedicated "à Monsieur Hugens de "Zulichem.")

2. A new Digester, or Engine for softening bones; containing the description of its make and use in these particulars:—viz. Cookery, Voyages at sea, Confectionary, Making of Drinks, Chymistry, and Dying. With an account of the Price a good big Engine will cost, and of the Profit it will afford. By Denys Papin, M.D., Fellow of the Royal Society. London, Printed for Henry Bonwicke, at the Red Lyon, in St. Paul's Churchyard. 1681. 4to.—(First edition of the curious work in question, and printed in consequence of an order of the council of the Royal Society, dated 8th December, 1680, and signed CHR. WREN.)

3. La manière d'amollir les os, et de faire cuir toutes sortes de viandes en peu de temps et à peu de frais, avec une description de la machine dont il faut se servir à cet effet. Paris, 1682. 12mo. (Erroneously stated by Ducoux to have been the

first edition. A still later edition, also in French, was published at Amsterdam, in 1688, in 12mo.)

4. A Continuation of the New Digester of Bones, &c.; sive continuatio novi Digestoris ossium autore Dionys. Papino, M.D., et Societatis Regiæ Socio. Londini, apud Joseph Streater. 1687, in 4to.

5. Recueil de diverses pièces touchant quelques nouvelles machinès. Cassel, 1695. 12mo.

6. Fasciculus dissertationum de novis quibusdam machinis atque aliis argumentis philosoph. Marburgii Cottorum, 1695. Small 8vo. Plates.—(A Translation of the 'Recueil;' see Brunet, Manuel des Libraires, 1843, v. PAPIN. M. Brunet, however, states that both the 'Recueil' and the 'Fasciculus' include the Treatise on 'La Manière d'amollir les Os;' from which we are led to imagine that this author, usually so accurate, has never had the advantage of seeing a copy of either the French or the Latin collection in question. We must confess ourselves to be similarly situated in regard to both of those rare, if not unique, works; the only information we possess as to their contents having been derived from the analyses of them given in the 'Philosophical Transactions' and the 'Acta Eruditorum.' See above, pp. 134-138.)

7. Nouvelle manière pour élever l'eau par la force du Feu, mise en lumière. Cassel, 1707. Small 8vo.

8. Ars nova ad aquam ignis adminiculo efficacissimè elevandam. Franc. 1707. 8vo.

2. *Papers by Papin, contained in the 'Philosophical 'Transactions.'*

1. Some experiments made in the Air-pump by Monsieur Papin, directed by Monsieur Hugens (as appears in the Discourse printed at Paris, 1674).

Phil. Trans., vol. x., *for the year* 1675, p. 443-447.

2. A particular account, given by an anonymous French author, in his book of the Origin of Fountains, printed 1674, at Paris, to show that the rain and snow waters are sufficient to make Fountains and Rivers run perpetually.

Ibid. p. 447-450.

3. Some experiments made in the Air-pump upon Plants; together with a way of taking exhausted Receivers away from off the said Engin: Tryed by the same Persons mention'd in Numb. 119, viz. Monsieur Hugens and M. Papin.

Ibid. p. 477-481.

4. A continuation of the experiments made by Monsieur Hugens, and M. Papin, in the Air-Pump; which are about the preservation of bodies.

Ibid. p. 492-495.

5. Some experiments touching animals, made in the Air-pump by the persons formerly mentioned, viz. Monsieur Hugens and M. Papin.

Ibid. p. 542-543.

6. Promiscuous experiments made in the Air-pump likewise, by the same persons.

Ibid. p. 544-548.

7. The description of a Siphon, performing the

same things with the Sipho Wurtemburgicus; invented by Dr. Papin, Fellow of the Royal Society.

Phil. Trans., vol. xv., *for* 1685, p. 847-848.

8. A new way of raising water; by Dr. Papin, Fellow of the Royal Society.

Ibid. p. 1093-1094.

9. Observations of Dr. Papin, Fellow of the Royal Society, on a French paper concerning a Perpetual Motion.

Ibid. p. 1240-1241.

10. A full description, with the use, of the new Contrivance for raising water, propounded in the Phil. Trans., No. 173; by Dr. Papin, Fellow of the R. S.

Ibid. p. 1274-1278.

11. An account of an experiment, shown before the Royal Society, of shooting by the rarefaction of the air. By Dr. D. Papin, R.S.S.

Phil. Trans., vol. xvi. *for* 1686 *and* 1687, p. 21-22.

12. Some further remarks on the instrument proposed by an anonymous French author, for effecting a perpetual motion, an account whereof is given in No. 177 of these Transactions, by Dr. Papin, M.D., R.S.S.

Ibid. p. 138-139.

13. A Demonstration of the Velocity wherewith the Air rushes into an exhausted receiver, lately produced before the R. Society, by Dr. D. Papin, Reg. Soc. S.

Ibid. p. 193-195.

14. The answer of Dr. Papin to several objec-

tions made by Mr. Nuis against his engine for raising water by the rarefaction of the air, whereof a description is given in No. 178 of these Transactions.

Phil. Trans., vol. xvi. *for* 1686 *and* 1687, p. 263-267.

15. An answer of the same to the author of the perpetual motion. *Ibid.* p. 267-268.

16. Account of a Book. A continuation of the new Digester of bones: It's improvements and new uses it hath been applyed to, both at Sea and Land. Together with some improvements and new uses of the Ayre Pump, tryed both in England and Italy. By D. Papin, M.D., Fellow of the Royal Society. *Ibid.* p. 329-332.

17. [Account of a Book.] Recueil de diverses Pieces touchant quelques nouvelles Machines, &c. Par Mr. D. Papin, Dr. en Med., &c. A Cassel, 1695. In 8vo. *Phil. Trans.*, vol. xix., *for* 1697, p. 483.

18. Part of a letter from Mr. D. Papin to Dr. Frederick Slare, Fellow of the College of Physicians and of the Royal Society, concerning an improvement of the Hessian bellows, &c.

Phil. Trans, vol. xxiv., *for* 1705, p. 1990-1992.

In the third and fourth volumes of Birch's History of the Royal Society * there are recorded

* "The History of the Royal Society of London for improving of "Natural Knowledge, from its first rise. In which the most con- "siderable of those papers communicated to the Society, which have "hitherto not been published, are inserted in their proper order, as a "Supplement to the Philosophical Transactions. By Thomas Birch, "D.D., Secretary to the Royal Society." London, 1757, 4 vols. 4to.

many experiments and observations communicated by Papin, as well as some details of the pecuniary aid, "convenient lodging in Gresham College," and further encouragement, which he received from the Society. From one of the earliest of those entries (vol. iii. p. 486), it appears that on the 22nd of May, 1679, Papin was introduced by Mr. Hooke; and from one of the last of them (vol. iv. p. 557), that "It was ordered that Dr. "Papin have a present of four copies of the *History* "*of Fishes*, and a letter testimonial, under the seal "of the Society, of the good services rendered them "by him."

To one of Hooke's works, also, viz. his "Lectures "de Potentiâ Restitutivâ, or of Spring," published in 1678, there is appended, among other "Collec- "tions," "Dr. Papin's Letter, containing a De- "scription of a Wind-Fountain, and his own "particular contrivance about the forcer of its "Syringe."

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3. *Papers by Papin, contained in the 'Acta Eruditorum Lipsiae.'*

1. [Account of the] "New Digester or Engine "for softening bones," &c., as published in England in 1681. 4to.

Act. Erud. for 1682, p. 105.

2. [Account of] "La maniere d'amolir les os," &c. Paris, 1682, 12mo. Translated from the English.

Ibid. p. 305.

3. D. Papini Experimentum Societati Regiæ Anglicanæ exhibitum, concernens jaculationem mediante aëris rarefactione efficiendam. Ex Transact. Philos. M. Jan. et Febr. 1686, n. 179, p. 21.

Act. Erud. for 1686, p. 500-501.

4. D. Papini, e Societate Regia Anglicana, inventa nova Hydragogica. Ex Transact. Philos. Anglic. Mens. Decemb. 1685, p. 1254 et 1274, seqq.

Ibid. p. 545-551.

5. A Continuation of the New Digester of Bones, &c., sive Continuatio novi Digestoris Ossium, autore Dionys. Papino, M.D. et Societatis Regiæ Socio :— necnon Augmenta quædam et Experimenta nova circa Antliam Pneumaticam, facta partim in Anglia, partim in Italia, communicata a Dionys. Papino, Med. D. et Soc. Reg. Angl. Socio. Londini, apud Joseph Streater, 1687, in 4to.

Act. Erud. for 1687, pp. 276-284, *and* 325-335.

6. Demonstratio velocitatis qua cum aër irruit intra exhaustum recipiens.

Act. Erud. for 1688, p. 156-158.

7. Dionysii Papini, Mathematum in Academia Marpurgensi hoc tempore Professoris, Meletemata ad geminam Appendicem de Perpetuo Mobili Actis Eruditorum Lipsiensibus A. 1687, M. Jun. pag. 315 seqq. insertam.

Ibid. p. 335-339.

8. Excerpta ex viri clarissimi, Dionysii Papini, Mathematum in Academia Marpurgensi Professoris

publici, litteris ad . . . . de Novo Pulveris Pyrii usu.

Act. Erud. for 1688, p. 497-501.

9. Additamentum ad Disquisitionem Dn. Papini do novo pyrii pulveris usu, mense proximo Septembri in Actis hisce pag. 497, exhibitam : De usu tuborum prægrandium ad propagandam in longinquum vim motricem fluviorum, &c. Communicatum a laudato Dn. Papino.

Ibid. p. 643-646.

10. Dionysii Papini Descriptio Torcularis, cujus in Actis Anni 1688, pag. 646, mentio facta fuit : Excerpta ex ejusdem litteris ad . . Marburgi d. 23 Dec. A. 1688, exaratis.

Act. Erud. for 1689, p. 96-101.

11. D. Papini De gravitatis causa et proprietatibus observationes.

Ibid. p. 183-188.

12. Ejusdem Examen machinæ Domini Perrault.

Ibid. p. 189-195.

13. Dion. Papini Rotatilis Suctor et pressor Hassiacus, in Serenissima aula Cassellana demonstratus et detectus.

Ibid. p. 317-322.

14. In J. B. Appendicem illam ad Perpetuum Mobile, Actis Novemb. A. 1688, pag. 592 sqq. insertam, Observationes D. P.

Ibid. p. 322-324.

15. Excerpta ex litteris Dn. Dion. Papini ad . . . de Instrumentis ad flammam sub aqua conservandam.

Ibid. p. 485-489.

16. Examen Siphonis Wurtemburgici in vertice effluentis. Excerpta ex Litteris Dn. Dion. Papin. ad . . . .

Act. Erud. for 1690, p. 223-228.

17. Dion. Papini Nova Methodus ad vires motrices validissimas levi pretio comparandas.

Ibid. p. 410-414.

18. Mechanicorum de viribus motricibus sententia, asserta a Dn. Papino adversus Cl. G. G. L. objectiones.

Act. Erud. for 1691, p. 6-13.

19. Dion. Papini observationes quædam circa materias ad Hydraulicam spectantes, Mensi Februario hujus anni insertas.

Ibid. p. 208-213.

20. [Account of] Fasciculus Dissertationum de novis quibusdam machinis atque aliis argumentis philosophicis. Autore Dionysio Papino, Med. Doct. Matheseos Prof. Publ. Marpurgensi. Marpurgi, 1695, in 8, plagg. 20, cum tribus plagg. figurarum.

No. V.

SPECIAL CASE IN THE COURT OF COMMON PLEAS, AND OPINIONS OF THE JUDGES THEREON, IN THE CAUSE BOULTON AND WATT VERSUS BULL, 16 MAY, 1795.*

In the Common Pleas.

BETWEEN

Matthew Boulton and James Watt . . . . *Plaintiffs.*

AND

Edward Bull . . . . . *Defendant.*

The Special Case.

Introduction. This was an action upon the case, for unlawfully infringing the privilege declared by an Act of Parliament made in the fifteenth year of his present Majesty's reign, intituled, 'An Act for vesting in James Watt, engineer, his executors, administrators, and assigns, the sole use and property of certain Steam-engines, commonly called Fire-engines, of his invention, described in the said Act, throughout his Majesty's dominions, for a limited time,' to be vested in the plaintiff James Watt, his executors, administrators, and assigns, of making, constructing, and selling certain engines, in the said Act particularly described, for the term of twenty-five

* From notes taken in short-hand by Mr. Gurney, and originally published in 1799.

years, by the defendant's making, constructing, and selling engines, in imitation of the said engines invented by the plaintiff James Watt, and secured to him and his assigns by the said Act, and of the like nature and kind as the said kind of engine so invented by the plaintiff James Watt, and by using and putting in practice the invention of the plaintiff James Watt, in the said Act mentioned, within the kingdom of Great Britain, during the said term; two-third parts of which said privileges had been granted and assigned by the plaintiff James Watt to the plaintiff Matthew Boulton; to which action the defendant pleaded the general issue, not guilty, and issue was thereupon joined.

Cause tried at the Sittings after Trinity term, 1793.

This cause came on to be tried at the sittings after Trinity term, one thousand seven hundred and ninety-three, held at Westminster-hall, in and for the county of Middlesex, before the Right Hon. the Lord Chief Justice Sir James Eyre, knight, and a special jury; when a verdict was given for the plaintiff, subject to the opinion of the Court on the following SPECIAL CASE:—

"His present Majesty, by letters patent dated "the fifth day of January, in the ninth year of his "reign, did give and grant unto the plaintiff James "Watt his special licence, full power, sole privi- "lege and authority; that he the plaintiff James "Watt, his executors, administrators, and assigns, "should and lawfully might, during the term of "fourteen years therein mentioned, use, exercise, "and vend, throughout that part of his Majesty's "kingdom of Great Britain called England, the

" dominion of Wales, and town of Berwick-upon-
" Tweed, and also in his Majesty's colonies and
" plantations abroad, the said James Watt's new-
" invented method of lessening the consumption of
" steam and fuel in fire engines; with a proviso
" for the said James Watt, by writing under his
" hand and seal, to cause a particular description of
" the nature of the said invention to be enrolled in
" his Majesty's High Court of Chancery within
" four calendar months after the date of the said
" letters patent.

" The plaintiff James Watt, in pursuance of the
" said proviso, did, by writing under his hand and
" seal, cause a specification or description of the
" nature of the said invention to be enrolled in his
" Majesty's High Court of Chancery, within the
" said time limited for that purpose; which descrip-
" tion is particularly set forth in the said Act of
" Parliament.

" In the fire engines referred to in the said spe-
" cification, and which were in use prior to the
" patent in question, motion was given to the
" piston by the pressure of the atmosphere acting
" upon one side thereof, while a vacuum, or certain
" degree of exhaustion, was produced on the other
" side, within the steam vessel denominated the
" cylinder, by means of the injection of cold water,
" whereby the steam was condensed; which opera-
" tion, prior to the invention of the said James
" Watt, was always performed in the steam vessel
" or cylinder itself.

" When the steam had been condensed, and the

" piston had descended, such portions of air and " water as remained under it within the steam " vessel or cylinder were expelled through valves " by the next succeeding steam from the boiler, " and that steam, counterbalancing the pressure of " the atmosphere at the open end of the cylinder, " allowed the piston to rise up with that end of the " lever to which it was attached, while the other " end of the lever, and the matters attached thereto, " descended, by reason of their greater comparative " weight, and thus the engine was restored to that " state in which it was previous to the first con- " densation.

" The steam was for this purpose, as occasion " required, admitted through a pipe from a distinct " vessel called the boiler, where it was generated, " which occasionally communicated with the cylin- " der by means of a valve, which was opened and " shut by the action of the engine.

" The injection of cold water was in like manner " admitted, as occasion required, into the cylinder, " through a pipe from another distinct vessel con- " taining cold water, called the injection cistern, by " means of a cock or valve, which was also opened " and shut by the action of the engine, and such " pumps as were used in these engines were also " wrought by the engines themselves.

" The construction and use of pumps for drawing " out air, elastic vapour, or water from places or " vessels where a vacuum or exhaustion was re- " quired, were known and practised before the " obtaining the letters patent abovementioned, but

" had not been applied to the cylinders or conden-
" sers of steam engines.

" The said invention of the said James Watt, was
" at the time of making the said letters patent, a new
" and an useful invention; and the said privilege,
" vested by the said Act of Parliament in the said
" James Watt and his assigns, *was infringed by the*
" *defendant in manner charged upon him by the de-*
" *claration.**

" The said specification made by the said James
" Watt is of itself sufficient to enable a mechanic,
" acquainted with the fire engines previously in
" use, to construct fire engines, producing the effect
" of lessening the consumption of fuel and steam
" in fire engines, upon the principle invented by
" the said James Watt.

" The questions for the opinion of the Court
" are,

Questions reserved.

" First, *Whether the said patent is good in law,*
" *and continued by the Act of Parliament above*
" *mentioned.*

" Second, *Whether the above specification of the*
" *plaintiff James Watt is, in point of law, sufficient*
" *to support the above patent.*

" If the opinion of the court shall be in favour
" of the plaintiff upon both these questions, then
" the above verdict for the plaintiffs is to stand:

" If not, then a verdict is to be entered for the
" defendant instead of the verdict given for the
" plaintiffs."

* See the Supplement, for the Counts in the Declaration against Bull.

On Saturday the sixteenth of May, one thousand seven hundred and ninety-five, this special case stood in the paper for judgment, when the Lord Chief Justice Eyre took notice that the court were divided upon the case, and would therefore deliver their opinions *seriatim*.

16th May, 1795. The opinion of the Court.

ROOKE, J.—In this cause of Boulton and Watt *v.* Bull, there is a special case stated for the opinion of the court; and the case is this. [*Reads the case.*]

From this state of the case, and from the admission of counsel on both sides, I assume the following facts. That the plaintiff Watt is the inventor of a new and useful improvement in fire engines, whereby the consumption of steam, and consequently of fuel, is considerably lessened: that the improvement is of such a nature that it may legally be the object of protection by royal patent: that a patent has been granted to the inventor on the condition of a specification of the nature of the invention: that a specification has been made sufficient to enable a mechanic to construct fire engines containing the improvement invented by the patentee: and that the legislature, six years after the patent had been granted, thought proper to extend the duration of the patent from eight years then to come to twenty-five years. The patent was granted the fifth of January, the ninth of the present King; the statute was the fifteenth of the present King.

Under these circumstances I think I conform to the spirit of the statute of 21 James I., cap. 3,

sec. 6, if I incline to support this patent; provided it may be supported without violating any rule of law: and I think so for these two reasons; first, because the patentee is substantially entitled to the protection of the patent; and, secondly, because the public are sufficiently instructed and will be duly benefited by the specification.

Against this claim of the patentee certain objections have been taken, which, it is contended, deprive him of all legal right to protection from it.

First, it is objected that the patent is not for fire engines upon the particular construction containing this new improvement, but for a new-invented method of lessening the consumption of steam and fuel.

Secondly, that no particular engine is described in this specification, but that the patentee only sets forth the principles.

And the last objection is, that the statute has not duly prolonged the patent, because the patent is for a method, and the statute for an engine.

It is to be observed that these objections are merely formal; they do not affect the substantial merits of the patentee, nor the meritorious consideration which the public have a right to receive, in return for the protection which the patentee claims.

As to the first objection, it is, that the patent is not for a fire engine of a particular construction, but for a new-invented method. The patent presupposes the existence of the fire engine, and gives a monopoly to the patentee of his new-invented

method of lessening the consumption of steam and fuel in fire engines: the obvious construction of these words is, that he has made an improvement in the construction of fire engines; for what does *method* mean but mode or manner of effecting? what method can there be of saving steam or fuel in engines, but by some variation of the construction of them? A new-invented method, therefore, conveys to my understanding the idea of a new mode of construction. I think those words are tantamount to fire engines of a newly-invented construction; at least I think they will bear this interpretation, if they do not necessarily exclude every other.

The specification shows this was the meaning of the words as understood by the patentee, for he has specified a new and particular mode of constructing fire engines. If he has so understood it, and if the words will bear this interpretation, then I think this objection, which is merely verbal, is answered: to which I add, that patents for a method, or art of doing particular things, have been so numerous, according to the lists left with us, that *method* may be considered as a common expression in instruments of this kind; it would, therefore, be extremely injurious to the interests of patentees to allow this verbal objection to prevail.

As to the second objection, that no particular engine is described, that no model or drawing is set forth, I hold this not to be necessary, provided the patentee so describes the improvement as to enable artists to adopt it when his mono-

poly expires. The jury find that he has so described it.

It is objected that he professes to set forth *principles* only; but we are not bound by what he professes to do, but by what he has really done: had he professed to set forth a full specification of his improvement, and had not set it forth intelligibly, his specification would have been insufficient, and his patent void. It seems, therefore, but reasonable that, if he sets forth his improvement intelligibly, his specification shall be supported, though he professes only to set forth the principle.

The term *principle* is equivocal: it may denote the *summum genus*, or the radical elementary truths of a science, or it may denote those consequential axioms which are founded on radical truths, but which are used as fundamental truths by those who do not find it expedient to have recourse to first principles.

The radical principles on which all steam engines are formed are the natural properties of steam, its expansiveness and condensibility: whether the machines are formed in one shape or another, whether the cylinder is kept hot or suffered to cool, whether condensed in one vessel or another, still the radical principles are the same.

When the present patentee set his inventive faculties to work, he found fire engines already in existence, and the two natural qualities of steam already known and mechanically used: he only invented an improvement in the mechanism by

which they might be employed to greater advantage. There is no newly-discovered natural principle as to steam, nor any new mechanical principle in his machine: the only invention is a new mechanical employment of principles already known.

As to the specification, some part of it, so much as represents the future intentions of the patentee, may be considered, according to the language of the specification, as theoretical only; but the greater part described a practical use of improved mechanism, the basis on which the improvement is founded.

The object of the patentee was to condense the steam without cooling the cylinder: the means adopted to effectuate this were to enclose the cylinder in a case which will confine the heat, or transmit it slowly, to surround it with steam or other heated bodies, and to suffer neither water or any other substance colder than the steam to enter or touch it during that time. These means are set forth.

The objection is, there is no drawing or model of a particular engine; but where is the necessity of such drawing or model, if the specification is intelligible without it? Had a drawing or model been made, and any man had copied the improvement and made a machine in a different form, no doubt that would have been an infringement of the patent. Why? Because the mechanical improvement would have been introduced into the machine, though the form was varied. It follows from thence that a mechanical improvement, and not

the form of the machine, is the object of the patent; and if the mechanical improvement is intelligibly specified, of which a jury must be the judges, whether the patentee calls it a principle, invention, or method, or by whatever appellation, we are not bound to consider his terms, but the real nature of his improvement, and the description he has given of it, and we may, I think, protect him without violating any rule of law.

As to the articles of the specification which denote intention only, and do not state the thing to be applied, I do not think he could maintain an action for breach of these articles, for he cannot anticipate the protection before he is entitled to it by practical accomplishment. But the patent is for a method already adopted, and the two first and most material articles are set forth as already accomplished; and the case states it was new and useful at the time of making this patent. I therefore consider the most essential parts of the patent—the keeping the cylinder hot, enclosing it in a case, and surrounding it with steam—as carried into practical effect at the time of the patent; and the defendant has infringed this, and I will presume, after a verdict where nominal damages only are given, that the evidence was applied to and the damages given for those articles only which are well specified. Now, if he has infringed on those articles which are well specified, he shall not be excused from an action because he has been guilty of an additional infringement on that which is specified as matter of intention only.

Upon the objection of the want of a drawing or model, that at first struck me as of great weight: I thought it would be difficult to ascertain what was an infringement of a method, if there was no *additional* representation of the improvement or thing methodized; but I have satisfied my mind thus: *infringement or not*—is the question for the jury. In order to decide this, they must understand the nature of this improvement or thing infringed. If they can understand this without a model, I am not aware of any rule of law which requires a model or a drawing to be set forth, or which makes void an intelligible specification of a mechanical improvement, merely because no drawing or model is annexed. In the present case I do not hear that the want of a drawing or a model occasioned any difficulty to this jury; they have expressly decided that Mr. Watt has the merit of a new and an useful invention, and that this invention was infringed by the defendant: how can I say that they could not understand this for want of a drawing, especially when the jury have added that the specification is sufficient to enable a mechanic, acquainted with the fire engines previously in use, to construct fire engines producing the effect of lessening the consumption of fuel and steam in fire engines, upon the principle invented by the plaintiff?

For these reasons I think the second objection, that no particular engine is set forth, is not of sufficient weight to destroy the effect of the patent.

As to the third, though the patent is for a method,

and the statute for fire engines of his invention, if I am right in my opinion that the expression "new-invented method of lessening the consumption of steam and fuel in fire engines" is tantamount to fire engines of a new construction to lessen the consumption of steam and fuel, it follows, that the patent and the statute are, in grammatical construction, for one and the same thing: that the patentee and the legislature intended they should be so, there can be no doubt. I consider the statute as a legislative comment on the patent, and I think it tends to illustrate and fortify, rather than invalidate the privilege which the plaintiffs claim.*

The arguments on the part of the defendant have not suggested to me any other objections which require a direct answer; the objections I have already noticed are, to my understanding, satisfactorily answered: I am therefore of opinion that the verdict ought to stand.

HEATH, J.—This patent is expressly for a new-invented method of lessening the consumption of steam and fuel in fire engines. It appears that the invention of the patentee is original, and may be the subject of a patent; but the question is, inasmuch as this invention is to be put in practice by the means of machinery, whether this patent ought not to have been for one or more machines, &c., or whether this is such a specification as entitles him to the monopoly of a method.

If method and machinery had been used by the

* Mr. Justice Rooke's answer to the third objection is omitted in Mr. H. Blackstone's Report of this case.

said patentee as convertible terms, and the same consequences would result from both, it might be too strong to say the inventor should lose the benefit of his patent by the misapplication of his term: in truth it is not so; his counsel have contended for the exclusive monopoly of a method of lessening the consumption of steam and fuel in fire engines, and that, therefore, would better answer the purposes of the patentee, for the method is a principle reduced to practice; it is in the present instance the general application of a principle to an old machine.

There is no doubt that the patentee might have obtained a patent for his machinery, because the Act of Parliament he obtained acknowledged his patent, and he himself, in one thousand seven hundred and eighty-two, procured a patent for his invention of certain new improvements upon steam and fire engines for raising water, &c., which contained new pieces of mechanism applicable to the same.

Upon this statement the following objections arise to the patent, which I cannot answer: namely, that if there may be two different species of patents, the one for an application of a principle to an old machine, and the other for a specific machine, one must be good and the other bad. The patent that admits the most lax interpretation should be bad, and the other alone conformable to the rules and principles of common law, and to the statute on which patents are founded.

The statute of 21 James I. prohibited all mo-

nopolies, reserving to the King, by an express proviso, so much of his ancient prerogative as shall enable him to grant letters patent and grants of privilege for the term of fourteen years or under, of the sole working or making of any manner of new manufactures within this realm, to the true and first inventor and inventors of such manufactures.

What then falls within the scope of the proviso are such manufactures as are reducible to two classes:—the first machinery; the second includes medicines formed by chemical and other processes, where the vendible substance is the thing produced, and that which operates preserves no permanent form.

In the first class the machine, and in the second class the substance produced, are the subjects of the patent.

I approve of the term *manufacture* in the statute, because it precludes all nice refinement; it gives us to understand the reason of the proviso, that it was introduced for the benefit of trade: that which is the subject of a patent ought to be specified, and it ought to be that which is vendible, otherwise it cannot be a manufacture.

This is a new species of manufacture; the novelty of the language is sufficient to excite alarm. It has been urged that other patents have been litigated and established; for instance, Dollond's, which was for a refracting telescope. I consider that as substantially an improved machine: a patent for an improvement of a refracting telescope, and

a patent for an improved refracting telescope, are in substance the same. The same specification would serve for both patents. The organization of parts is the same in both.

I asked, in the argument, for an instance of a patent for a method * * * * * * and none such could be produced. I was then pressed with patents for chemical processes, many of which are for a method; but that is from an inaccuracy of expression, because the patent, in truth, is for a vendible substance, neither of which were produced in a new way.

To pursue this train of reasoning still further, I shall consider how far the arguments in support of this patent will apply to the invention of original machinery founded on a new principle. The steam engine furnishes an instance. The Marquis of Worcester discovered, in the last century, the expansive force of steam, and first applied it to machinery. As the original inventor, he was clearly entitled to a patent: would the patent have been good to be applied to all machinery, or to the machine to which he had discovered it might be applied? The patent decides the matter.

It must be for the vendible matter, and not for the principle.

Another objection may be urged against the patent, upon the application of the principle to an old machine, which is, that whatever machinery may be hereafter invented would be an infringement of the patent, if it be founded on the same principle. If this were so, it would reverse the

clearest positions of law respecting patents for machinery, by which it has been always held that the organization of a machine may be the subject of a patent, but principles cannot be so,

If the argument for the patentee could be correct, it would follow, that, where a patent was obtained for the principle, the organization would be of no consequence; therefore the patent for the application of the principle must be as bad as the patent for the principle itself.

It has been urged for the patentee, that the patentee could not specify all the cases to which his machinery could be applied: the answer seems obvious, that what he cannot specify he has not invented.

The finding of the jury, that steam engines may be made upon the principle stated by the patentee, by a mechanic acquainted with the fire engines previously in use, is not conclusive.

This patent extends to all machinery that may be made on this principle, so that he has taken a patent for more than he has specified; and as the subject of his patent is an entire thing, the want of a full specification is a breach of the conditions, and avoids the patent. Indeed it seems impossible to specify a principle and application to all cases, and that furnishes an argument that it cannot be the subject of a patent.

It has been usual to examine the specification as a condition on which the patent has been granted. I shall now consider it in another point of view; for it is a clear principle that the subject of every

grant must be certain. The usual mode has been for the patentee to describe the subject of it by the specification. The patent and the specification should contain a full description. Then in this, as in most other cases, the patent would be void, for the uncertain description of the thing granted, if it were not aided by the statute. The grant of a method is not good, because uncertain; the specification of [a] method or application of principle is equally so, for the reasons I have alleged.

BULLER, J.—Few men possess more ingenuity, or have more merit with the public, than the plaintiffs on this record; and if their patent can be sustained in point of law, no man ought to envy them the profits and advantages arising from it; and if it cannot be supported, no man ought to envy them the profits which they have received, because the world has undoubtedly derived great advantage from their ingenuity. We are called upon to deliver our opinions on the dry question of law, whether, upon the case disclosed to us, this patent can or cannot be sustained; and I shall deliver my opinion, first, upon the case itself, and, secondly, on the arguments which have been urged at the bar.

The case states the plaintiffs' patent, specification, and the Act of Parliament; it gives a description of the old engine, and then it states that the plaintiffs' is a new and useful invention, and that the specification is sufficient to enable a mechanic to construct fire engines, producing the effect of lessening the consumption of fuel and steam in fire engines, upon the principle invented by Mr. Watt.

One objection made by the defendant's counsel was, that it did not appear on the case that a mechanic could, from the specification, construct an engine which would lessen the consumption of fuel and steam with equal effect, or to the same extent as Watt did. If the negative appeared, namely, that a mechanic could not from the specification make an engine with equal effect, or if it required expense and experiments before it could be done, I agree that either of those facts would avoid the patent; but that is not so stated, and upon this case I think we are bound to say there is no foundation for either of these objections.

There is another objection to the case, which I think more important, and that is, that the jury have not told us wherein the invention consists, whether it be in the addition of a cylinder or other vessel to an old machine, or what the addition is, or whether it be in the application to the old parts of the machine, or what is called at the bar the principle only, or in what this principle consists.

These defects have opened a great deal of argument, and driven the plaintiffs' counsel to the necessity of supporting his case on all possible grounds.

The old engine consisted of a cylinder, a boiler, and a pipe, which occasionally communicated between an injection cistern and pump.

The two material parts of the new engine, as mentioned in the specification, are the old cylinder, now called the steam vessel, and the vessel now called the condenser, which, it is said, must be dis-

tinct from the steam vessel, though occasionally communicating with it. The old boiler did occasionally communicate with the cylinder. The pumps and other things are admitted to be trifling.

Upon this state of the case I cannot say that there is anything substantially new in the manufacture; and, indeed, it was expressly admitted on the argument that there were no new particulars in the mechanism. It was said it was not a machine invented; the mechanism was not pretended to be invented: that this engine does consist of all the same parts as the old engine, and that the particular mechanism is not necessary to be considered.

The fact of there being nothing new in the engine drove the counsel to argue on very wide grounds, and to touch on the possibility of maintaining a patent for an idea or principle, though at the close of the reply it was, I think, admitted, that a patent could not be sustained on an idea or principle alone. The very statement of what a principle is proves it; it is the first grounds and rules for arts and sciences; or, in other words, the elements and rudiments of them. A patent must be for some new production from those elements, and not for the elements themselves.

The plaintiffs' case is considerably distressed in many parts of it, and the arguments adduced were calculated to keep clear of difficulties, which the counsel foresaw might be introduced: as, first, if the principle should be supported, there may be some danger of confirming the defendant's objection to the patent.

Secondly, if independent of the principle it should be supported, it may offer a fatal objection to the specification, because that does not state how the new machine is to be constructed.

Or thirdly, because, unless the patent embraces the new principle, then another objection may arise, both to the patent and the specification, that the patent is granted for the old machine, and not for the improvement only.

Perhaps it may have been convenient and judicious to keep these objections as much as possible in the background, and out of the view of the Court; but it is our duty to sift and dive into the facts and circumstances of the case, and the bearings and consequences of them, as far as our abilities and knowledge of this subject will admit.

There is one short observation arising on this part of the case, which seems to me to be unanswerable; and that is, that if the principle alone be the foundation of the patent, it cannot possibly stand with that knowledge and discovery which the world were in possession of before. The effect, the power, and operation of steam were known long before the date of this patent: all machines which are worked by steam are worked on the same principle. The principle was known before; and if the principle alone be the foundation of the patent, though the addition may be a great improvement, as it certainly is, yet the patent must be void *ab initio*.

But then it was said, though an idea or principle alone will not support the patent, yet an idea re-

duced to practice, or the practical application of a principle, was a good foundation for a patent, and was the present case.

The mere application or mode of using a thing was admitted in the reply not to be a sufficient ground; for upon the Court's putting the question, it was allowed that, if a man of science invents a new method of using a thing known before, he could not have a patent for that. The method and mode of doing a thing are the same, and I think it impossible to support a patent for a method only, without having carried that method into effect, and produced some new substance.

But here it is necessary to inquire what is a principle reduced into practice.

It can only mean practice founded on principle, and that practice is the thing done or made; in other words, the manufacture. This brings us to the true foundation of all patents, which must be the manufacture itself. So says the statute of James I. All monopolies, except those allowed by the statute, are declared to be illegal and void, as they were at common law.

The 6th section excepts only the true and first inventor and inventors of manufactures, and whether the manufactures be with or without principle, produced by accident or art, is immaterial. Unless this patent can be supported for the manufacture, it cannot, in my opinion, be supported at all. I think that the patent is given for the manufacture, and I agree with my brother Adair that verbal criticisms ought not to avail, but that principle in

the patent and engine in the Act of Parliament mean the same thing; besides, the declaration is founded on the right to an engine, and therefore, unless the plaintiffs can make out their right to that extent, they must fail.

In most of the instances of patents mentioned by my brother Adair, the patents were for manufactures, and the specifications rightly stated the methods by which the manufactures were made, but none go the length of proving that a method of doing a thing without the thing's being done is a good foundation for a patent: when the thing is done or produced, then it becomes the manufacture, which is the proper subject of the patent.

Dollond's patent was for object-glasses, and his specification merely stated the method of making these glasses; and, as I stated in the course of the argument, the point contested in that case was whether Dollond or Hall was the first inventor; Hall having first made the discovery in his own closet, but never made it public; and on that ground it was that Dollond's patent was confirmed.

Mechanical and chemical discoveries all come within the description of manufactures, and it is no objection to either of them that the articles of which they are composed were known and in use before, provided the compound article, which is the object of the invention, is new; but then the patent must be for the specific manufacture produced.

The first inventor of a fire engine could never

have supported a patent for a method and principle of using fire; nor could Dr. James, supposing his patent had been clear of other objections, have maintained a patent for a method or principle of using antimony.

Supposing the world were better informed than it is how to prepare James's fever powders, and an ingenious physician were to find out that they were useful in consumptions, could he have a patent for the sole use of James's powders in consumptions, or to be given in particular quantities? I think it must be conceded that such a patent would be void, and yet the use and effect of the medicine would be different from what is now known. So in the case of a late discovery, (which is said to succeed),—giving arsenic for agues,—could a patent be supported for that? The medicine is the manufacture, and the only object of the patent; and the medicine not being new, any patent for the employment of it would be void.

The case of water tabbies may afford some illustration of the subject. That invention first owed its rise to the accident of a man's spitting on a floor-cloth, which changes colour, and from thence he reasoned on the effect of mixing water with oils, and he invented water tabbies. His patent was for water tabbies; but if he could have obtained a patent for the principle of mixing oils with water, no man could have used that for any other species of manufacture.

The true question in this case is, whether the plaintiffs' patent can be supported for the engine?

I have already said I consider it as given for the engine; and if that be the right construction of the patent, that alone lays all the arguments about ideas and principles out of the case.

The objections to this patent as for the engine are two: first, the fire engine was known before; and, secondly, the specification is for an improvement, and he has taken a patent for the whole machine.

As to the first, the plaintiffs' counsel were forced to admit that there was nothing new in the machine. That is decisive against the patent; and the second objection, I think, is equally fatal.

That a patent for an addition or improvement may be maintained, is a point which has been never directly decided, and Burford's case, 3 Inst. 184, is an express authority against it; for that case was decided in the Exchequer Chamber by all the judges. What were the particular facts of the case we are not informed; and there seems to me to be more quaintness than solidity in the reason assigned, which is, that it was to put but a new button to an old coat, and that it is much easier to add than to invent.

In truth, arts and sciences at that period were at so low an ebb, in comparison with what they have been advanced since, and the effect and utility of improvements so little known, that I do not think that case ought to preclude the question. In later times, when the point has arisen, the inclination of the court has been to support the patent for the improvement, and the parties have

acquiesced where the question might have been brought directly before the court. In Morris *v.* Branson, tried in the sittings after Easter 1776, the patent was for making oilet-holes, &c.

Lord Mansfield said, after one of the former trials of this patent, he had received a very sensible letter from one of the jury on the subject, suggesting whether, on the principle of public policy, there could be a patent for an addition only.

Lord Mansfield said, the defendant may move in arrest of judgment; but his lordship added, that objection would go to repel almost every patent that ever was granted. There was a verdict for the plaintiff in that case, with 500*l.* damages, and yet no motion was made in arrest of judgment.

Though his lordship did not mention the opinions of the judges, nor his own, yet one may safely collect that he thought, on great consideration, that patent was good.

Since that time it has been the generally received opinion in Westminster Hall that a patent for an addition is good; but then it must be for the addition only, and not for the whole machine. In Jessop's case, as was quoted by my brother Adair, the patent was held to be void, because it extended to the whole watch, and the invention was a particular movement only.

It was admitted in the reply, that the patent should be applied to the invention itself; on which I observe, if the patent be confined to the invention, it can give no right to the engine, nor anything beyond the invention itself. Where the

patent is taken for an improvement only, the public has a right to purchase that, without being encumbered with other things. A fire engine of any considerable size, I take it, will cost 1200*l.*; and suppose the alteration by the plaintiff will cost 500*l.*, must it be contended that every person who has a fire engine now must buy new ones, or be excluded the use of the improvement? So in a watch: may not a person buy a new movement, and work it up himself? Where men have neither engines nor watches, it is highly probable they will go to the inventor of the last improvement: and if so, it is the advantage which the inventor gets from the option of mankind, but not from a patent.

EYRE, LORD CHIEF JUSTICE.—Upon this case two questions are reserved for the opinion of the court.

The first is, whether the patent is good in law, and continued by the Act of Parliament mentioned in the case.

The second is, whether the specification stated in the case is in point of law sufficient to support the patent. As I take it, the facts of the case are stated with a view to the application of them to these questions, and not to any other questions which may be thought to arise upon them. Perhaps, indeed, if the court saw that another material question might arise out of these facts, which had escaped the attention of the court and jury at *Nisi Prius*, they might direct the case to be amended, or might direct a new trial to be had in order to introduce it.

These two questions were thus stated in order

to bring before the court the points of law insisted on upon the part of the defendant, and also to give an opportunity for considering a doubt which occurred to me, upon my first view of the case, at the trial, which was this, whether a patent right could attach upon anything not organised, and capable of precise specification. As these two questions are framed, there are, therefore, three points for the consideration of the court:

First, whether the patent was in its original creation good or bad:

Secondly, taking it to be good, whether it was continued by the Act of Parliament:

And thirdly, taking it to be good in its original creation, and to have been continued by the Act of Parliament, subject to an objection for want of a specification, whether there has been a sufficient specification.

Though we have had many cases upon patents, yet I think we are here upon ground which is yet untrod, at least till this cause was instituted, and until the discussions were had which we have heard at the bar, and more from the Court. Patent rights are nowhere, that I can find, accurately discussed in our books. Sir Edward Coke discourses largely, and sometimes not quite intelligibly, upon monopolies, in his Chapter on Monopolies, 3. Institute, 181, but he deals very much in generals, and says little or nothing of patent rights, as opposed to monopolies. He refers principally to his own report of the case of monopolies, in 11 Coke; he also mentions a resolution of all

the judges in 2 and 3 Elizabeth, from a MS. of Dyer, condemning a grant to the corporation of Southampton, by Philip and Mary, for the sole import of Malmsey wine, and that no Malmsey wine should be landed at any other place upon pain to pay treble costs.

He also mentions a case in the Exchequer Chamber in 15 Elizabeth, for a privilege concerning the preparing and melting of lead ore; but he states no particulars; and the principle on which that case was determined has been, as my brother Buller observes, not adhered to, namely, that an addition to a manufacture cannot be the subject of a patent.

There is also a case in Godbolt, and there are a few other cases, condemning particular patents, which were beyond all doubt mere monopolies.

The modern cases have chiefly turned upon the specifications, whether there was a fair disclosure; so was the case of Turner *v.* Winter in 1 Term Reports. The case of Edgeberry *v.* Stevens, in 2 Salkeld 447, is almost the only case upon the patent right, under the saving of the statute of James, that is to be found. That case establishes that the first introducer of an invention practised beyond sea shall be deemed the first inventor: it is there said the Act intended to encourage new devices useful to the kingdom; and whether acquired by travel or study, the book says it is the same thing. Deriving so little assistance from our books, let us resort to the statute itself, (the statute 21 James I. cap. 3): we shall there find

monopoly to be the privilege of the sole buying and selling, making, and working, any manner of manufactures within this realm; and this is generally condemned as contrary to the fundamental laws of the land: but the 5th and 6th sections of that statute save letters patent and grants of privileges of the sole working or making of any manner of a new manufacture within this realm, to the first and true inventor or inventors of such manufactures, with this qualification, "So they be "not contrary to law, nor mischievous to the "state," in these three respects; first, "by raising "the prices of commodities at home;" secondly, "by being hurtful to trade;" or thirdly, "by "being generally inconvenient." According to the letter of the statute, the saving goes only to the *sole working* and *making*; and the *sole buying*, *selling*, and *using*, remain under the general prohibition, and with apparent good reason for so remaining; for the exclusive privilege of *buying*, *selling*, and *using*, could hardly be brought within the qualification of not being contrary to law, and mischievous to the state in the respects abovementioned. I observe also, that, according to the letter of the statute, the words, "*any manner of* "*new manufacture*," in the saving, fall very short of the words "anything" in the first section. But most certainly the exposition of the statute, as far as usage will expound it, has gone very much beyond the letter. In the case in Salkeld, the words "new devices" are substituted, and used as synonymous to the words "*new manufacture*."

It was admitted, in the argument at the bar, that the word "*manufacture*" in the statute was of extensive signification, and that it applied not only to things made, but to the practice of making, to principles carried into practice in a new manner, to new results of principles carried into practice. Let us pursue this admission. Under things made we may class, in the first place, new compositions of things, such as manufactures in the most ordinary sense of the word. Secondly, all mechanical inventions, whether made to produce old or new effects; for a new piece of mechanism is certainly a thing made. Under the practice of *making* we may class all new artificial manners of operating with the hand, or with the instruments in common use, new processes in any art producing effects useful to the public: When the effect produced is some new substance or composition of things, it should seem that the privilege of the sole working or making ought to be for such new substance or composition of things, without regard to the mechanism or process by which it has been produced, by which, though also new, it will be only useful as producing the new substance; and upon this ground Dollond's patent was, perhaps, exceptionable, for that was for a method of *producing* a new object-glass, instead of for the object-glass *produced*. If Dr. James's patent had been for his method of *preparing* his powders, instead of the powders themselves, that patent would have been exceptionable upon the same ground.

When the effect produced is no substance or

composition of things, the patent can only be for the mechanism, if new mechanism is used; or if no new mechanism is used, for the process, if it be a new method of operating, with or without old mechanism, by which the effect is produced.

To illustrate this: the effect produced by Mr. David Hartley's invention for securing buildings from fire is no substance or composition of things; it is a mere negative quality, the absence of fire. This effect is produced by a new method of disposing of iron plates in buildings.

In the nature of things, the patent could not be for the effect produced. I think it could not be for the making the plates of iron, which, when disposed in a particular manner, produced the effect, for these are articles in common use; but the invention consisted in the method of disposing those plates of iron so as to produce their effect, and that effect a useful and meritorious effect. Hartley's patent seems to have been very properly granted to him for his *method* of securing buildings from fire.

This compendious analysis of new "manufac-" tures" in the statute satisfies my doubt whether anything could be the subject of a patent but something organized and capable of precise specification. But for the more satisfactory solution of the other points which are made in this case, I shall pursue this subject a little further. In Mr. Hartley's method, plates of iron are the means which he employs, but he did not invent those means. The invention wholly consisted in the new manner of

using, or, I would rather say, of *disposing* a thing in common use, and which thing every man might make at his pleasure; and this therefore could not, in my judgment, be the subject of his patent. In the nature of things it must be, that, in the carrying into execution any new invention, use must be made of certain means proper for the operation. Manual labour, to a certain degree, must always be employed; the tools of artists frequently, frequently things manufactured but not new invented, such as Hartley's iron plates, all the common utensils used in conducting any process, and so up to the most complicated machinery that the art of man ever devised. Now let the merit of the invention be what it may, it is evident that the patent, in almost all these cases, cannot be granted for the means by which it acts, for in them there is nothing new, and in some of them there is nothing capable of appropriation. Even where the most complicated machinery is used, if the machinery itself is not newly invented, but only conducted by the skill of the inventor so as to produce a new effect, the patent cannot be for the machinery. In Hartley's case it could not be either for the effect produced, for the effect, as I have already observed, is merely negative, though it was meritorious.

In the list of patents which I have been furnished with, there are several for new methods of manufacturing articles in common use, where the sole merit and the whole effect produced are the saving of time and expense, and thereby lowering the

price of the article, and introducing it into more general use. Now I think these methods may be said to be new manufactures, in one of the common acceptations of the word; as we speak of the manufacture of glass, or any other article. The advantages to the public from improvements of this kind are, beyond all calculation, important to a commercial country, and the ingenuity of artists who turn their thoughts towards such improvements is of itself deserving of encouragement, and, in my apprehension, it is strictly agreeable to the meaning and spirit of the statute of King James that it should be encouraged; and yet the validity of these patents, in point of law, must rest upon the same foundation as that of Mr. Hartley's patent. The patent cannot be for the effect produced; for it is either no substance at all, or, what is exactly the same thing as to a question upon a patent, no new substance, but an old substance produced advantageously for the public. It cannot be for the mechanism, for there is no new mechanism employed; it must then, in my apprehension, be for the method; and I would say, in the very significant words of Lord Mansfield in the case of the copyright, it must be for method detached from all physical existence whatever; and I think we should well consider what we do in this case, that we may not shake the foundations upon which these patents stand. I believe I do not over-rate it when I state two-thirds, I believe I might say three-fourths, of all patents granted since the statute passed, are for methods of

operating, producing no new substance, and employing no new machinery. If you look at the list, I dare say you will find fifty patents for methods of producing all the known salts, either the *simple* salts or the old compounds. The different sorts of processes used in manufactures, [are], many of them, inventions of great merit, many of them probably mere speculations of wild projectors; these latter will fall, the others ought to stand.

If we wanted an illustration of the visible merit of a new method of operating with old machinery, we might look to the identical case now in judgment before the court: if we consider into what general use fire engines are come; that our mines cannot be worked without them; that they are essentially necessary to the carrying on many of our principal manufactures; that these engines are worked at an enormous expense in coals, which in some parts of the kingdom can with difficulty be procured at all in large quantities, it is most manifest that any method found out for lessening the consumption of steam in the engines, which, by necessary consequence, lessens the consumption of coals expended in working them, will be of great public and national benefit, as well as a benefit to the individual who thinks fit to adopt it; and shall it now be said, after we have been in the habit of seeing patents granted in the immense number in which they have been granted, for methods of using old machinery to produce substances that were old, but producing them in a

more beneficial manner; for producing negative qualities by which benefits result to the public; shall we now, by a narrow construction of the word *manufacture* in this statute, say, that there can be no patent for methods producing this new and salutary effect, connected, and intimately connected, with the trade and manufactures of the country? I confess I am not prepared to say that.

An improper use of the word principle, in the specification set forth in this case, has, I think, served to puzzle it. Undoubtedly there can be no patent for a mere principle; but for a principle so far embodied and connected with corporeal substances as to be in a condition to act, and to produce effects in any art, trade, mystery, or manual occupation, I think there may be a patent. Now this is, in my judgment, what the patent stated in this case was granted for; and this is what the specification stated in the case describes, though it miscalls it a principle. It is not that the patentee has conceived an abstract notion that the consumption of steam or fire engines may be lessened, but he has discovered a practical manner of doing it; and for that practical manner of doing it he has taken his patent. Surely this is a very different thing from taking a patent for a principle; it is not for principle, but it is for a process.

I have dwelt the more largely upon this part of the case, because, in my apprehension, this is the foundation upon which the whole argument will be found to rest.

If, upon the construction of the statute, there may be a patent for a new method of manufacturing, for conducting chemical processes, or working old machinery so as to produce new and useful effects, then I am warranted to conclude that this patent was in its original creation good.

I will now consider the specification before I proceed to the consideration of the statute for continuing this. The specification has reference to the patent, and not to the statute. I distinctly admit that, if this patent is to be taken to be a patent for a fire engine, the specification is not sufficient; it is not a specification of a machine of any determinate form, having component parts capable of precise arrangement, and of particular description. On the other hand, if the patent is not for a fire engine, but is in effect for a manner of working a fire engine so as to lessen the consumption of steam,—which, as I conceive, the words of the patent import,—let us see whether this specification does not sufficiently describe the manner of working fire engines so as to produce the effect expressed in the patent, and whether the only objection to the specification is not that it is loaded with a redundancy of superfluous matter.

The substance of the specification is a discovery that the condensing the steam out of the cylinder, and protecting the cylinder from the external air, and keeping the cylinder hot to the degree of steam-heat, will lessen the consumption of steam. This is no abstract principle; it is in its very statement clothed with practical application; it

points out what is to be done in order to lessen the consumption of steam. Now the specification of such a discovery seems to consist in nothing more than saying to the constructor of a fire engine, For the future condense your steam out of the body of the cylinder, instead of condensing it within it; and put something round the cylinder to protect it from the external air; and keep your piston air-tight without water. Any particular manner of doing this, one should think, would hardly be needed to be pointed out; for one should hardly suppose that a workman capable of constructing a fire engine would not be able to do that which the specification requires him to do; but if a very stupid workman should want to know how to go about this improvement, and, in answer to his question, was directed to conduct the steam which was to be condensed from the cylinder into a close vessel kept sufficiently cold by means of a pipe and a valve, and to draw air which was not condensed out of the condensers, and was also told to enclose the cylinder in a wooden case, and to use resinous substances instead of water to keep the piston air-tight,—can it be imagined that he would be so stupid as not to execute this improvement with the assistance of these plain directions? If any man could for a moment imagine that this was possible, I observe that this difficulty is put an end to, because the jury have found that a workman can execute this improvement in consequence of the specification. Some machinery, it is true, must be employed;

but the machinery is not of the essence of the invention; it is incidental to it, because the steam must pass from the cylinder to the condensing vessel, and for that purpose there must be a valve to open a pipe to convey and a vessel to receive the steam; but this cannot be a new-invented machinery, and therefore there can be no patent for this addition. Suppose a new-invented chemical process, and the specification should direct that some particular chemical substance should be poured upon gold in a state of fusion, it would be necessary, in order to this operation, that the gold should be put into a crucible, and should be melted in that crucible; but it would be hardly necessary to state in the specification the manner in which, or the utensils with which, the operation of putting gold into a state of fusion was to be effected; they are mere incidents, which every man acquainted with the subject is familiar with.

Some observation was made in the course of the argument at the bar on its being left unascertained by the specification and case to what extent the consumption of steam would be lessened by the invention, but the method does not profess to ascertain this: it professes to lessen the consumption; and, to make the patent good, the method must be capable to lessen the consumption to such an extent as to make the invention useful: more is not necessary, and absolute precision is not practicable. The quantity of steam saved in each machine must depend upon a great variety of circumstances respecting each individual fire engine,

such as the accuracy of casting or boring the cylinder, or the dimensions of it; the care and diligence of keeping the cylinder in a proper degree of heat; and a more or less perfect order for working in which the fire engine is kept. This will all affect the quantity of steam to be lessened.

Some weighty observations have been made upon parts of this specification, but those parts appear to me not properly to relate to the method described in the patent; they are rather intimations of new projects of improvements in fire engines, and some of them, I am very ready to confess, either very loosely described or not very accurately conceived. I do not undertake to pronounce which, but one or the other is pretty clear. I believe they are the fourth and fifth articles; the first, second, third, and sixth appear to me to belong to this method, and very clearly point out and explain the method to every man who has a common acquaintance with the subject, and intelligible even to those who have no practical acquaintance with the subject. If there be a specification to be found in that paper which goes to the subject of the invention, as described in the patent, I think the rest may be very well rejected as superfluous. If, indeed, the defendant will show that he has not violated the invention, which is sufficiently specified, but that what he has done hath a reference to another method of lessening the consumption of steam, to which the questionable parts of the specification were meant to relate, the objection to the specification would have been made, and perhaps

some other objections alluded to might have been taken both to the patent and specification; but I would observe here, with regard to this and some other difficulties, that there is nothing reserved in this case respecting the manner of the infringement of the patent; the general fact only is stated; and on the consideration of a case reserved, we are not to search for difficulties upon which the parties have not chosen to state any point to us for our judgment, and into which I think we are not at liberty to go. The difficulty which struck me, as it did my brother Buller, [is] with respect to the declaration, as applied to the patent as it originally stood, not as it now stands continued by the Act of Parliament;—if we were at liberty to go into that, a great difficulty would arise upon it, and that difficulty might produce a nonsuit, that nonsuit a new action, in which the difficulty would be removed, and I thought it therefore wisely avoided.

Now, supposing the difficulty upon the patent itself, and the difficulty upon the specification to be got over, the Act of Parliament is the next thing that remains to be considered; and to state the objection to the Act in the strongest manner, it would amount to this, that the Act continues a patent for a machine, when in fact this patent is for a process.

It is to be observed that there is nothing technical in the composition or in the language of an Act of Parliament. In the exposition of statutes the intent of the Parliament is the guide. It is expressly laid down in our books that every statute

ought to be expounded not according to the letter, but according to the intent. (I shall be understood not to be speaking of penal statutes.) I refer you to 2 Roll's Abridgment, 118, to Plowden, 350-363. The doctrine has been carried into effect by cases. If a corporation be misnamed in an Act of Parliament, if it appear that this corporation was intended, it is sufficient. (10 Coke, 57).

Where, in the statute of *Quia Emptores*, it is said, "every one shall hold of the Lord Paramount '*secundum quantitatem terræ*,'" &c., this is taken and ought to be intended "*secundum valorem terræ*." It shall be construed according to the value of the land, and not according to the quantity, for so was the intent. This is in Plowden, 10 and 57.

We all know that an Act of Parliament may be extended by equity; no authority has been cited which amounts to proof that a mistake in point of description in an Act of Parliament of this nature, when the true meaning can be discovered, and when there is a foundation for the action to ground itself upon, shall vitiate the Act. The case that was cited to us from Plowden's Commentaries differs essentially from this case. In that case it gave effect to a supposed legal attainder, and proceeded upon it altogether. If the groundwork fell, and there was no legal attainder, nothing remained; the supposed attainder in that case did fall; consequently all fell. Now the difference between that case and this lies here: here the patent meant to be described exists, and is, in my opinion, a good patent, and

may therefore be a groundwork to support the Act.

The case was compared to the case of the King being deceived in his grant; but I am not satisfied that the King, proceeding by and with the advice of Parliament, is in that case in which he is under the special protection of the law, and that he could on that ground be considered as deceived in his grant, and no case was cited to prove that. And therefore, upon the general and wide ground, I am of opinion that the Act has continued the patent.

The objection on the Act of Parliament is of the same nature as one of the objections to the specification. The specification calls a *method* of lessening the consumption of steam in fire engines a *principle*, which it is not; the Act calls it an *engine*, which perhaps also it is not; but both the specification and statute are referrible to the same object, mean the same thing exactly, and, when they are taken with their correlative, are perfectly intelligible.

A narrower ground was taken in the argument, and that was to expound the word *engine* in the body of this Act, in opposition to the title of the Act, to mean a *method*; and I am ready to say I would resort to this, if necessary, in order to support the patent; and let it be remembered that, though monopolies, in consideration of law, are odious, the consideration of the privilege created by this patent is meritorious.

I conclude that the judgment ought to be for the plaintiffs.

Now this difficulty arises by the Court's being divided in their opinions, it will be necessary to consider what shall be done. When the cause was before me at *Nisi Prius*, it was proposed there should be a *special verdict*; it was thought the easier and the cheaper way, if the opinion of the Court could be taken with effect upon a *special case*, that the facts that were thought to be material should be stated in that manner; which was assented to, but, as I recollect, with an understanding that, if it should become necessary, the facts should be put in a *special verdict*.

ADAIR, SERJEANT.—It certainly was so.

EYRE, LORD CHIEF JUSTICE.—Then the next thing is, what is now to be done, when the Court is unfortunately in the situation of being divided?

ADAIR, SERJEANT.—If any interposition of the Court appears to be necessary upon the difficulty that arises, your Lordships will permit us to consider till Monday whether we shall make any and what application.

No. VI.

SPEECH OF MR. ROUS, COUNSEL FOR MESSRS. BOULTON AND WATT, DEFENDANTS IN THE PROCEEDINGS IN ERROR IN THE CAUSE BOULTON AND WATT VERSUS HORNBLOWER AND MABERLY, IN THE COURT OF KING'S BENCH, HILARY TERM, 1799.*

WHEN I state to the Court that a very large sum to the individual will depend on the event of this cause; when I suggest that, in my humble opinion, no patent can stand if the reasoning on which this is impeached shall be adopted by the Court, I only mean to claim the patient attention of your Lordships, and to offer an apology for myself, if I should deviate, in a case of much novelty, from the ordinary course of legal argument. Can it seriously be contended that the invention of Mr. Watt, which, during the space of nearly thirty years, has been admired by all Europe as the greatest practical advance ever made in the arts, is a mere abstract discovery in science? Can that which with a single bushel of coals will raise a foot high thirty millions of pounds weight, or six thousand hogsheads of water; which has brought into subjection to man, and submitted

* This speech was delivered by the learned counsel *from a written paper*. The few copies of it which were afterwards printed, (but not published), for the use of Mr. Watt and his friends have now become excessively scarce.

to his use, a power more than double the force of gunpowder; which has taught a beam moving with this mighty force to act as the pendulum of a clock, and keep pace with other clocks through the day; can these operations be performed by a mere abstract idea, neither tangible nor vendible? If these gentlemen were to approach this intangible substance, as they are pleased to call it, with the same ignorance of what it is with which they discourse upon it, they would probably be crushed like flies, and leave no trace of their existence.

Can it be seriously contended that a thing is not vendible, which Mr. Watt has been employed at a great price to erect in every part of this kingdom? The sole contention in the cause is, who shall have the privilege of making what is supposed to have no real existence, this intangible substance; and of selling what is supposed not to be vendible.

Such paradoxes are fit only for the amusement of children. I feel ashamed to suppose it possible dreams like these can be seriously entertained by a court of justice; yet it will be my duty to develope the metaphysical sophistry by which these paradoxes have been sustained.

The waste of ingenuity which has been employed on this subject recals to my mind a very ingenious tract by Dr. Berkeley, late Bishop of Cloyne, to prove that the material world has no reality, exists only in idea. The whole sophistry of his book depends on a misapprehension of Mr. Locke's reasoning respecting the secondary qualities of matter. Grant him his first error, and I

defy any man to defeat his conclusion; yet everybody sees and feels the absurdity of rejecting the evidence of our senses respecting the material world, when, from our senses alone, we can obtain any knowledge whatsoever of the material world, or of its existence. In the same manner our present adversaries reason for the most part justly. Their error is a total misconception, real or affected, of what the thing is about which they reason, or, in other words, in what the invention of Mr. Watt consists.

If I can convey to the minds of others my own conception of this great discovery, there will be an end of all contest. All difficulties will vanish, and our adversaries themselves, upon their own principles, must give judgment in favour of my client. Definitions are dangerous, not merely to all reasoners, but often to the cause of truth; because no man can be certain that his mind embraces all the relations of the subject defined, much less that his language conveys distinct ideas of these relations to the minds of others.

Nothing less than a habit of correct communication can render definitions very useful. I do not therefore affect to define, especially in this stage of the argument; yet to give some general ideas may be useful in guiding the attention of the court.

The object of Mr. Watt was to save fuel and steam in fire engines. This is the grand desideratum. Power to any extent may be had. The important question always was, and ever must be,

at what price? He who reflects to what an infinitude of useful purposes power once obtained can be applied, will easily apprehend the importance of that discovery, which, with a single bushel of coals, will raise a foot high thirty millions of pounds weight.

As to obtain power at a cheap rate by lessening the consumption of fuel was the object, the invention, or the means, was a new combination of mechanical parts, which in common sense and common language constituted a new engine.

The specification does, as it ought, give directions for forming this combination of parts for doing the thing required.

The Act of Parliament speaks of the thing done under the term "engines of Mr. Watt's invention."

Where is the contradiction, except in the puzzled misconceptions of those who wish to confound us? If I am fully understood, *Causa dicta, res adjudicata est.* I shall, however, endeavour to crush all future cavil, by dividing the subject into distinct heads, and examining each apart.

1. The subject naturally requires that I should first examine the statute of James, and show that this embraces in intention and in terms the whole circle of the arts.

2. To show what is the invention of Mr. Watt, and that this invention is far, very far indeed, within the boundary of this description.

3. That the jury have found as a fact what I can demonstrate, that the specification is sufficient to enable an artist to construct the thing invented.

4. That the Act of the 15th of the present King, in language not to be misunderstood, continues to Mr. Watt the sole right of using this invention; or, in other words, the sole right of making and vending the thing invented,—the engine so constructed,—which for more than twenty years has obtained the familiar name of Mr. Watt's engine.

In handling these divisions, I mean to show that some verbal criticisms are mere misapprehensions of the meaning of language, and really nothing more.

The Act of King James declares all monopolies void, but saves, by a proviso, all patents for the sole "working or making of any manner of new "manufacture to the first inventor or inventors."

The obvious meaning of the legislature was, by the first part of the Act, to prohibit all useless restraints on the industry of the people; and, by the exception, to give encouragement to all useful inventions.

The terms employed embrace the whole circle of the arts, because by every beneficial invention in the arts the interests of a commercial nation are advanced.

If we look into dictionaries for the meaning of the word "manufacture," it is defined "works of "art," or the making of anything by art.

If we look to the word itself, it means anything made by hands, or rather, (as here used), the art of making anything with hands. It describes therefore the works of man, as contradistinguished

from the works of God;—of arts as opposed to science; for science is conversant with nature only, and with the relations which the great Author of Nature has thought fit to establish.

That the legislature here meant the art of making anything, is plain from the context; for they have secured to the first inventor not the thing made, but "the sole working or making of "any manner of new manufacture," plainly pointing out by the terms employed, that they did not even require that the thing manufactured or produced should be new. If the manner or method of making it be new, this alone will be sufficient to support a patent; and the reason is as plain as the construction, for a new improved method of making a thing already known, by a more simple process, and at a less expense, will often be more valuable than the first invention; and to a commercial nation the cheapness of the commodity, excluding the competition of other nations, is of the last importance. To this consideration, so deeply affecting the public interest in future, let me add that three-fourths of the patents heretofore granted, at all periods since the passing of the Act, are of this nature, and will be declared void by a judgment of the Court narrowing this construction.

The form of the patent itself, that well-considered precedent which has been used for more than a century, confirms this construction. Reciting the object of the legislature, it professes to carry that object into execution in these terms:

" We, being willing to give encouragement to all " arts and inventions which may be for the public " good, are graciously pleased," &c.

The authors of this form, therefore, understood the Act of Parliament to embrace the whole circle of the arts, and their interpretation of the Act has been adopted and confirmed by all subsequent Chancellors and Attorneys-General to the present hour. From 1693 to 1793 I find more than two hundred patents granted for methods of doing a thing. A multitude of these during the time of the accurate Lord Hardwicke, and the practice continues. Of this nature is Mr. Hartley's patent for preventing fires, which engaged the attention of the public and of Parliament. He did not invent the tin plates, but the method of applying them to prevent the passage of air.

Of this nature must be all inventions producing any effect by chemical process. Neither the fire, nor the alembic, nor the furnace, are invented by the patentee, nor the ingredients, but the method of preparing them. Nor is any property claimed in the result: for if I can produce the same result by different means, I do not encroach upon the patent. And every man knows that in chemical process this is eternally the case. The nobleman who extracted tar and pitch from coals claimed no property in tar and pitch, nor in coals, but in the method of extracting tar and pitch from coals.

Thus any man may make magnesia, but Dr. Glass's method of making magnesia is his property. A process to fix colours in printing linens

is an useful and important discovery, but the author can claim no property in the colour fixed, only in the method of doing it. A very large proportion of the patents granted are for new and improved methods of making old things, things already in common use. The more common and general the use of any article, the greater the demand for it, the more important is the discovery of a cheap and simple process in the making. The inventor, however, does not claim the sole making or vending an article in common use before he existed; but merely the "sole working "or making of his new manufacture," of the article in question. The exclusive use of his invention is his reward; and he leaves to others the free enjoyment of what the public had before, —all other methods of making the same thing.

If the Court wish to learn to what extent these observations are founded in the practice of the last hundred years, a list of patents has been prepared for the inspection of your Lordships; and it will be found no language can impress the importance of this part of the subject so strongly, as the examination of these numerous patents in detail.*

Some of these patents are for inventions which approach very near the confines of speculative science. The practical application to useful production alone constitutes the distinction, and even this application is sometimes, from the nature of things, extremely general. I have selected, for the purpose of illustrating this observation, the

* See Supplement, pp. 277–291, *infra*.

patent and specification of Mr. Dollond, which is described as "a new method of making the object-"glasses of refracting telescopes, by compounding "mediums of different refracting qualities."

That every ray of light refracted by a lens was, by the different refrangibility of its parts, divided into different colours, and thereby shed an obscurity over the image formed in the telescope, was one defect which Mr. Dollond proposed to remove. Before his time it was thought that this refrangibility, and consequent dispersion of the parts, bore an exact proportion to the mean refractive power of the lens. But Mr. Dollond discovered the proportion of this dispersive power to be different in glasses of different qualities. He therefore conceived the possibility, by opposing the refractive powers of glasses of different qualities, to re-unite the parts of the ray where the image is formed in the telescope, without destroying that mean refraction which is necessary to form this image: and he succeeded.

In teaching us how to produce this effect, he says it may be done by two or more glasses; and, accordingly, some opticians employ two convex and one concave glass, while other opticians employ only one of each form. Neither does Mr. Dollond give us the curvatures of these glasses, or their proportions to each other. Nor was it possible to be more specific, because the proportions in the form of the glasses must depend on the proportion which the relative qualities of the individual glasses bear to each other: and these, we know, vary almost infinitely. The selection, moreover, of

these glasses, must rest in the choice of the artist making the individual telescope. To give, therefore, specific proportions, was physically impossible. When the principle of the invention was explained, the adjustment of its parts was necessarily left to the skill of the optician in the formation of each individual telescope.

The refractive powers of these glasses being unequal, a just proportion of the radii of their surfaces corrected the other defect of the telescope, which opticians call the aberration of light. But no more specific directions could be given on this head, because this proportion must likewise depend on the respective qualities of the opposed glasses.

This patent of Mr. Dollond underwent an eager litigation, both in the Court of Common Pleas and in the King's Bench; and was established in both Courts. It may therefore be regarded as the most solemn decision we have on the subject of patents. Yet it is plain that the discovery of Mr. Dollond consists not in any organization of parts, of which we have heard so much, but in the practical application of a principle of science to produce a specific effect in the construction of the object-glasses of refracting telescopes; and it is the production of this specific effect which distinguishes this invention from a mere abstract discovery in science, which cannot be the object of a patent.

This patent, moreover, could not give Mr. Dollond even the exclusive right of making the glasses so employed, because convex and concave

glasses of every quality were used in telescopes before Mr. Dollond was born. His invention merely was, by uniting these glasses, as the object-glass of a telescope, to remove the two defects, the dispersion of the parts of light, which coloured the object, and the aberration of light, which gave a false proportion and shape to the object. Mr. Dollond's invention is a principle, a *modus operandi*, to produce a new effect; and yet this is universally acknowledged to be a great improvement in the art of making telescopes.

The Act of King James extends, therefore, in principle and language, to every beneficial method of production, to the whole circle of the arts, as contradistinguished from science; and has been so acted upon nearly two hundred years. In making this extensive claim, I do it for the sake of others, not of Mr. Watt. He has invented a new construction of a steam engine, or a steam engine of a new construction, for these are convertible propositions. In the correct use of language, if you speak of a thing to be done, you describe the method of doing it; if you speak of the thing as done, you give it the appellation which the thing made has acquired. Thus we say, Savery's engine, Newcomen's engine, Watt's engine, when we speak of the steam engine, having the peculiar character of their respective inventions. The sole distinction which the present subject requires is, that when we make a specification we must strictly confine ourselves to that combination of parts which is of the author's invention; because this

specification is intended to describe what the invention is; the party having no right to restrain others from the use of anything which he has not invented.

Before I proceed to explain the invention of Mr. Watt, permit me to get rid of a fallacy which has been introduced to perplex this part of the subject. The defendant has affirmed in his assignment of error that the invention is of a principle only. If by principle be meant an abstract discovery of science, I deny the fact; but if principle be here used in its genuine correct sense, as derived from the Latin *principium*,—the beginning, the source, the cause, or, in other words, the method of producing any given result,—then, I say, this term embraces every invention that ever was made in the progress of the arts. We are, however, on the horns of a dilemma. It is a principle, and is not a formed organized machine. Here again we need only explain the terms to expose the nonsense. If by organized machine be meant a steam engine having the peculiar characteristic distinction of Mr. Watt's invention, the common sense of mankind has decided the question. This engine has been known for near thirty years by the denomination of Watt's fire engine. If by the terms organized machine be meant an engine, all the parts of which are of the author's invention, then I answer, no such invention has ever been made by man since the passing of the Act. A new combination of parts is all that has been invented by any one; and this Mr. Watt has invented in the

present instance. A single sentence will prove this truth. All the mechanical powers have been known at least two thousand years, and every piece of mechanism is an application of one, or a combination of several of these powers. No man therefore, for two thousand years, can have invented the whole of any machine. The truth is, that a new combination to produce a given effect, is the distinguishing character of every invention, which separates it from every other invention, and gives it, if I may so express myself, its personal identity.

As much has been said about the invention of an engine, and an improvement of an engine, (a distinction which has no existence but in words), this part of the subject will deserve further illustration. That I may not be suspected of warping my reasoning for the purpose of this cause, I have chosen to illustrate the argument from a very simple yet ingenious machine which we have all seen. I mean a machine exhibited in the shop of Mr. Bramah, for applying the equal pressure of water to the purposes of a press; an invention which avoids the friction of the screw, and is infinitely superior. With my finger and thumb, without effort, I have raised with this machine twenty tons. Yet no one part of this machine was invented by the author; his merit is a combination of parts already in use, to produce a new specific effect. The machine consists of a small forcing pump, driving water through a small orifice into a close vessel, where it acts upon a piston of larger dia-

meter. The force is multiplied exactly in the proportion which the end of the piston, exposed to the action of the water, bears to the pump, and the orifice through which the water is forced.

Does this discovery consist in applying the pressure of water in a close vessel? Every book of hydrostatics teaches it. We see in every book of this sort the machine by which a man, pouring a pint of water into a small tube, lifts his own weight; or, by pouring water into a longer tube, bursts the strongest cask. Does it consist in the application of the forcing pump to drive water through an orifice? The name forcing pump designates its use; and the thing was known to antiquity. Does the invention consist in the use of the piston? The piston was acted upon in the same manner by steam, instead of water, for near a century, in the fire engine. In what does the invention consist, but in the combination of parts, antecedently known, to a new use? And even these parts may be greatly varied, when the hint is once given, without departing from the invention. If I substitute another force for the pump,—change the shape of the close vessel,—make the piston square, hexagon, octagon,—all the world would nevertheless readily pronounce, that I had stolen the author's invention.

I could in the same manner dissect every other mechanical invention; but, having shown what the nature of mechanical invention must be, I shall now proceed to explain what the peculiar invention of Mr. Watt is; but to make language on this

subject intelligible, I must first call your attention to the state of the arts on similar machines at the time when this discovery was made.

In the middle of the last century the Marquis of Worcester first invented, and a Captain Savery afterwards executed, the first steam engine. This was nothing more than a substitution of the alternate expansion and condensation of steam, in the place of the piston of the forcing pump. It consisted of a strong close vessel, communicating by a pipe with the water to be raised, and by another pipe with the higher place to which the water was intended to be conveyed. In each pipe there was a valve opening upwards. When the steam was admitted into the close vessel it expelled the air, which, having no other passage, passed through the upper valve: that valve then shut, and, the steam in the close vessel being condensed by a jet of cold water, the atmosphere pressing on the surface of the water below raised it to fill that space. The steam, being again admitted, drove this water upwards; and thus the alternate expansion and condensation acted in the same manner as the piston of a forcing pump. The defect of this machine was this, that, the steam coming into immediate contact with the cold water, so large a proportion of the steam was condensed before it raised the water, that the expense of fuel was greater than the force or power acquired was worth. This ingenious machine fell therefore into disuse, was neglected and forgotten. In the beginning of this century Mr. Newcomen observed that

steam could not be employed to advantage in the place of a piston, in immediate contact with the cold water. He therefore formed his machine with a piston moving in a cylinder, and, admitting the steam below the piston, to counterbalance the pressure of the atmosphere above the piston, condensed the steam in the same manner as Savery had done with a jet of cold water. A vacuum being thus obtained, the piston descended with the weight of the atmosphere. I say this was the whole of Newcomen's invention: for he admitted and condensed the steam precisely in the same manner with Savery; and the working gear, (as it is called), by which the stroke of the machine is made to open and shut the valves at proper intervals, was a subsequent discovery. Mr. Newcomen, having thus contrived to move his piston by the alternate pressure of the steam below and of the atmosphere above, hung this piston to the handle of a common pump; or, in other words, hung it to one end of a beam balanced on its centre, the other end of which beam worked a common pump. This was the whole of Mr. Newcomen's engine, for which he well deserved the thanks of mankind. Archimedes is said to have boasted that, if he had a spot on which to fix his instruments, he would move this solid globe. This boast, regarding it as such, proves at least that the desideratum in mechanics was not mere power. He who gives power at a cheap price is the benefactor to mankind: this it is which constitutes the value of the invention. In this view the invention of Newcomen was a prodigious stride

in the arts, for he raised a foot high, with a single bushel of coals, eight millions of pounds weight. Mankind for nearly a century have agreed to denominate this invention Newcomen's engine. When, therefore, Mr. Watt, by a new construction, has raised with the same fuel, (instead of eight), thirty millions of pounds weight, what impropriety can there be in denominating a machine of this new construction Watt's engine? The invention of Mr. Watt has more of novelty, more of science; and, as a stride in the advancement of the arts, is infinitely more gigantic.

Mr. Watt, by reflection, discovered the defects of this machine of Newcomen, the causes of those defects, and invented a remedy. Steam is condensed by contact with any bodies colder than itself. It must therefore happen that when the condensation took place by the injection of cold water, the cylinder had become much colder than steam. The evaporation also of the water on the piston carried off much heat. To restore this heat so lost, much steam was wasted before the remaining steam could act in raising the piston. Again, when the condensation was attempted, the cylinder retained much of its former heat, consequently the condensation was imperfect; and much steam remained to resist the descent of the piston. In short, to describe the defects of this machine in a sentence, I may say that, as the engine made ten strokes in a minute, to render the machine perfect, the cylinder ought to be as hot as steam and as cold as the atmosphere, alternately, ten times in every minute.

This being physically impossible, it occurred that, if the steam was made to act in one vessel kept always hot, and condensed in another vessel kept always cold, the object was attained. Before this idea could be executed, two other difficulties remained to be overcome. In the former engine of Newcomen the piston was rendered air and steam tight by water upon it. In the descent of the piston this water evaporated, and evaporation is the greatest cooler in nature, carries off more heat than any other cause yet known. By evaporation ice is formed even in a hot climate. In the place of water, Mr. Watt applied to the piston the fat of animals, and the other substances enumerated in his specification. These will not evaporate with the heat of steam. No obstacle therefore remained to keeping the cylinder hot. It might be enclosed; the steam might be employed to press on the piston above, by the same means it had been before made to act below, or alternately above and below, at the pleasure of the artist. The other difficulty respected the vessel called the condenser. With the jet of cold water a certain portion of air is introduced, and this air, with the damp of the steam, forms a mixed vapour, which, though little felt in one or two strokes of the engine, will, if suffered to accumulate, in time choke the engine. In the former engine of Newcomen this vapour was driven out by the admission of fresh steam, and escaped through the snifting valve. When the condensation was performed in a separate vessel, into which the steam was never admitted but for

the purpose of condensation, and was condensed as fast as it entered, this mixed vapour could not be expelled by the same means. Mr. Watt therefore applied a pump to extract this vapour. Thus far, whoever reads the specification must see, Mr. Watt had carried his invention. Yet some men have supposed this invention was not then complete. It demonstrably was complete and perfect, unless means can be found of taking more than all of any given substance. The steam in this engine of Mr. Watt never comes in contact with any substance colder than itself, until it has done its office. No part is, therefore, condensed, until its whole power has been obtained. When it has acted, it is so condensed, that no resistance remains, for the barometer proves a vacuum to be obtained nearly as perfect as by the exhaustion of the air-pump. The other mechanism of the steam engine is continually improving, and Mr. Watt's Parallel Motion alone will immortalize his name as a mechanic; but this peculiar invention, for which this patent has been obtained, was from the first perfect and complete, has never been improved, and from the nature of things never can, because it is impossible to have more than all.

I flatter myself I have proved that Mr. Watt has invented a new construction of parts to lessen the consumption of steam and fuel in fire engines, perfect in its kind. But this is a work of mere supererogation. The verdict entitles me to assume all I have laboured to prove; and to call on my learned friend to demonstrate, from what appears

on the present record, that this cannot be an invention within the Act of Parliament. Otherwise he cannot be entitled to arrest the judgment. The verdict finds:—

1st. Mr. Watt to be the true inventor.

2nd. That he did enrol a specification, which did describe and ascertain the nature of his said invention, and the manner in which the same is to be performed, according to the form and effect of the said proviso in the patent. From the bare inspection of the specification, your lordships are now required to pronounce two not very consistent propositions.

1st. That you see clearly what the invention is, and that it is not an invention within the Act of King James.

2ndly. That the specification is so imperfect, that it does not sufficiently describe the invention, even to an artist.

If I have been so fortunate as to make myself intelligible, I have already proved that the invention consists in a combination of solid material parts, producing a most powerful effect, beyond the example of all former times. We have done, therefore, with the first proposition, and all the nonsense about substances neither tangible nor vendible, which ignorance of the thing invented has introduced into the cause.

On the second proposition, I admit it was incumbent on Mr. Watt so to describe his invention, that an artist might be able, at the expiration of the patent, to make the thing invented, from the specification.

It seems to me, however, this is, and ever must

be, a pure question of fact, and in this case is already found by the verdict of the jury. The conclusion sought, whether the description be sufficient, must depend not merely on the terms used in the deed enrolled, but likewise on the actual state of the arts, and the ordinary degree of skill possessed by the artists to whom the instructions to make the thing invented are properly addressed. I presume it will not be contended that the movement of a watch need be described in terms to be comprehended by an anchor-smith; or the peculiar mode of constructing this fire engine, by a tailor or a shoemaker.

When the extreme case is put, every one sees the absurdity; but with all due deference to the superior learning of my own profession, the reasoning is equally applicable to the greatest talents and most profound knowledge of the law. To judge of the sufficiency of this description, requires a knowledge of mechanics which a lawyer may, or may not possess, and peculiarly of that mechanism which, at the time of the invention, was employed in steam or fire engines. In truth, the sufficiency of the specification is averred as a fact, and is found by the verdict of the jury upon the most satisfactory evidence. Five or six witnesses proved that they had actually made the engine from these instructions, or less. The testimony of Professor Robison on this head was striking. In recommending this engine in his public character in Russia, he had no sooner explained the idea of the separate condenser, than an

engineer instantly sketched the engine, and the similitude to that now in use was almost exact. Another engineer, who superintended twelve of Newcomen's engines in Yorkshire, under a misapprehension respecting the time at which the patent would expire, had actually formed and prepared all the parts, which have since been used with complete success. Added to this species of testimony, we called all the most eminent theorists, and practical engineers of all descriptions, who swore that to construct the engine from this description was so perfectly easy, that no man of tolerable skill in his profession could mistake. Yet my learned friend, from the bare inspection of the specification, has undertaken to prove, that all these eminent men are either ignorant fools or perjured knaves, and modestly asks the Court to declare this by their judgment.

I should here take my leave of the specification, did not the whole argument turn on this instrument; for, after verdict, my learned friend has no other materials from which he can show that this invention is neither tangible nor vendible, has no material substance, nor any organized parts. Here, again, the Court is required to pronounce the same judgment on the witnesses and two juries, who have known the invention as a new construction of a machine of most powerful effect.

If the Court will be so good as to carry in their minds what was proved at the trial, the actual state of Newcomen's engine, nothing can be more plain than this specification.

Having told us the effect of his discovery to save steam, and consequently fuel, in fire engines, he proceeds to point out the means of performing his invention. We must remember the first defect to be removed was, that a large portion of steam was wasted by coming into contact with bodies colder than itself, viz. the cylinder and piston, cooled by the injection of cold water, and the evaporation of the water above the piston. The method of correcting this defect is, by not suffering water or other cold substances to enter or touch the cylinder or steam vessel during the operation, by enclosing it in wood, or other substances that transmit heat slowly, by surrounding it with steam or other heated substances.

Before this direction could be executed, some substitute must be found for water, to keep the piston air-tight. Mr. Watt enumerates the substances which will answer this purpose.

Where is the difficulty of execution? As one of the witnesses, Mr. De Luc, observed, any man who could put on his own great-coat could execute this part of the invention.

But we are told, that Mr. Watt has defrauded the public; he has not given the most beneficial enjoyment of his invention. If his directions are followed, no part of the steam comes into contact with bodies colder than itself. No part of the steam is, therefore, condensed, until it has performed its office,—until it has pressed upon the piston. The public, therefore, have from this invention the full use of all the steam generated from the

fuel employed, and it is physically impossible to give them more than all.

But it seems the thing invented has no tangible substance! How can a cylinder be enclosed and kept hot with an abstract idea? Good God! is it really necessary, that our adversaries' heads should encounter the wood here spoken of, in order to dissipate the metaphysical jargon, by which a plain subject is attempted to be perplexed?

We now come to the other part of the invention,—for it consists of two parts,—viz. that the steam was to act in a vessel kept always hot, and be condensed in a vessel kept always cold. Mr. Watt tells us the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; and these vessels, which he calls condensers, he directs to be kept cold by the application of water or other cold bodies.

Was it necessary to explain the occasions of opening and shutting this communication? Who, that ever heard of a fire engine, but knew that the action of steam depended on its being confined? In Newcomen's engine it was confined until it had raised the piston. Was it necessary to add, that when the steam had done its office, and was to be destroyed by condensation, that the communication with the vessel in which it was to be condensed must be opened? Was it necessary to mention the valves, or the manner in which these valves were to be opened or shut by the working gear of the engine? All these means were

already in use, and so applied. All these things were therefore properly and necessarily omitted, for these constituted no part of the invention of Mr. Watt. The same reasoning applies to the means employed of condensing the steam. The injection of cold water now in use had been employed by Savery and Newcomen for a century and a half.

They quarrel with us for not giving a form of a condenser. Neither form, nor size, nor position of the condenser is material. To have specified these would have been to deceive. When the valve is opened, the steam, from its elastic nature, escapes, and is condensed. If there be any choice as to form, size, or position, these must depend on the local means of keeping the condenser cold; and when the artist is told that it must be kept cold, he has every information on these heads which an artist can require.

Nothing more is now to be done but to get rid of the air and elastic vapour, which cannot be removed by the means before employed. This Mr. Watt directs us to extract by a pump, worked by the engine, or otherwise, at the pleasure of the artist. To complete the invention of Mr. Watt, it was only necessary that this vapour should not be suffered to accumulate. The common mode of doing this, is to suspend the pump to the working beam of the engine.

I presume it will not be disputed, that the condenser and the pumps are tangible and vendible substances. As to the perfection of this part of

the invention, I cannot demonstrate it to be equal to the perfection of the other part, by the bare inspection of the specification. I must refer my adversary to the testimony of witnesses, and the evidence of the gauge annexed to the engine. From these he will learn, that the exhaustion is nearly equal to that of the air-pump, and, consequently, that all sensible resistance to the action of the piston is removed.

Mr. Watt tells us that he intends to employ the expansive power of steam to act on the piston in the place of the atmosphere. Here it was only necessary to state his intention, for he had before removed the water from the upper part of the piston, which formed the sole obstacle. After this water was removed, the steam might be admitted above the piston, by the same means employed by Newcomen to admit it below, or alternately above and below, at the pleasure of the artist.

Before I quit this part of the subject, permit me to answer a verbal criticism on the word "prin-"ciple" employed. If dictionaries be consulted, principle, in its proper original sense, means beginning, or cause, or constituent part; and in its secondary and figurative sense is only used for an abstract discovery in science. But why inquire in what sense the word principle ought to be used, when the sense in which it is actually used must be manifest? The principles here spoken of by Mr. Watt are the constituent parts of his invention. My invention, he says, consists, *i. e.* is constituted, of the following principles;—Of what?

He proceeds to tells us;—of his separate condenser, his pump, the solid enclosure of his cylinder, and the fat of animals applied to the piston: and surely these principles are sufficiently solid, tangible, and vendible, to satisfy the dullest apprehension what meaning the word was intended to convey.

The last remaining objection which has been made in this cause is, that the right obtained under the patent is not continued by the Act of Parliament. I am not aware of any rule of law, upon which the plain and manifest intention of the legislature can be defeated by the most incorrect use of terms; yet I am content to meet our adversaries on every objection; and this last difficulty, I trust, a small portion of common sense will easily remove. The enacting clause secures to Mr. Watt the sole privilege and advantage of making, constructing, and selling "the said en-"gines hereinbefore particularly described." The sole description in the Act is the specification. The term "engines" is, therefore, identified with the invention of Mr. Watt.

Yet, if it be further necessary to inquire to what the term "engines" refers, it may be observed, in the title of the Act, they are described as "certain "steam engines, commonly called fire engines, of "his, Mr. Watt's, invention."

In the preamble, they are first mentioned by reference to the patent; the effect of which is stated to be a grant of "the sole benefit and ad-"vantage of making and vending certain engines,

" by him invented for lessening the consumption " of steam and fuel in fire engines." Here engines, in fire engines, must mean a part, not the whole. The preamble then recites that, in compliance with the proviso or condition of this grant, he had enrolled a specification; this specification is then recited *verbatim*, by which the invention appears to have for its object to lessen the consumption of fuel and steam in fire engines, and to employ, as the means of producing this effect, to enclose the steam vessel or cylinder, and keep it hot; to remove water from the piston by substituting the fat of animals; to condense the steam in separate vessels kept cold in the manner directed, and to extract the vapour arising from condensation by a pump. The preamble then, as if to preclude all possible mistake, contrasts these engines, invented by Mr. Watt, with the common engines before in use, as something distinct and different from them. The Act then, in the enacting clause, uses the terms of reference, " the said engines herein par- " ticularly described," referring to the specification; but, what alone precludes all controversy respecting the meaning of these terms, it is afterwards expressly provided, that nothing in this Act shall extend to prevent any persons " making or " using any fire or steam engine, or any particular " contrivance relating thereto, which is not at " present of the invention of the said J. Watt, or " which are not particularly specified in this Act."

Then follows another proviso, " that every " objection competent against the patent shall be

"competent against this Act, to all intents and "purposes, except so far as relates to the term "hereby granted."

Can words more clearly express that the term of years granted is prolonged by the Act, and nothing more?

The use of the term "engine" in the Act having been treated as a serious difficulty, permit me to say a few words more on this subject. The first combination of mechanical parts to employ the action of steam has, for a century and half, been known by the name of Savery's engine. The next improvement, made by a different combination of parts, has been known nearly for a century by the name of Newcomen's engine. When the Act passed, the invention of Mr. Watt, which has a greater novelty in the combination of its parts than Newcomen's, was beginning to be known by the description of Watt's engine, a name which has since ripened into common use. If the use of this term was to be examined with all the acumen of critical severity, the use of it is correct. By what authority shall the question of criticism be decided? Our old friend Horace says—

"Licuit semperque licebit,
"Signatum præsente notâ producere nomen."

And again—

"Multa renascentur, quæ jam cecidere: Cadentque
"Quæ nunc sunt in honore vocabula, si volet usus,
"*Quem penes arbitrium* est, et jus et norma loquendi."

According to the rules of severest criticism, I maintain, therefore, that the term "engines of Mr.

"Watt's invention" correctly describes the thing for which the patent was obtained.

The separate condenser, with the subsidiary means of executing the design of a separate condensation, forms the peculiar characteristic quality of this invention, and justly denominates the engine, having this peculiar character, Mr. Watt's engine.

But the Act itself has left nothing to be inferred. It has defined what the legislature meant by the term engine, by an express reference to the specification and the patent; and has told us, that the effect of the language here used shall be, to prolong the term of the patent, and nothing more. If, therefore, any other word in the English language had been employed, the most absurd and incorrect that imagination can suggest, yet, when the legislature had thus defined what they meant by the word so employed, I humbly submit it would become the duty of a Court of Justice to carry this intention of the legislature, so declared, into execution.

Mr. Watt has been supposed to be answerable for every word in the preamble; and it has even been hinted, that inaccuracies or misrecitals in the preamble will make the Act void. To prove this extraordinary proposition, the case of the Earl of Leicester* and Heydon has been relied upon. This was a grant, by Parliament, of an estate supposed to have been forfeited for treason;—it appeared no attainder had taken place. What was the intention

* Plowd. 390.

of Parliament? Not to grant the estate of an innocent person, of a man not convicted. The fact not existing on which Parliament professed to proceed, of course the Act was void; because the intention of Parliament applied to a case which had no real existence. But does this prove that an Act of Parliament, where the intention is manifest, can be repealed in a Court of Justice, because judges do not assent to the preamble?

This preamble is in substance, as well as form, the language of the legislature; for the Act was much contested. The legislature are supposed to recite, that the invention was not discovered when the patent passed, and this immediately after reciting the specification annexed to the patent, as describing the invention; and in an Act of Parliament purposely made to prolong the term granted by the patent to the inventor; and, yet more absurdly, where every objection competent against the patent is expressly declared to be equally competent against the Act of Parliament. It would here be sufficient to state that the fact of the invention previous to the patent is averred in the declaration, and found conclusively by the verdict. I ought, however, to vindicate the Act of Parliament from such childish and absurd imputations.

This part of the preamble professes to state the general grounds of Mr. Watt's claim to a prolongation of his patent beyond the term allowed to other inventions. It begins with the time and expense he had employed in many experiments on steam and steam engines, by which, it is affirmed, very

considerable advantages over the common engines are acquired; so far, plainly refers to a period of time antecedent to the patent; but that, on account of the time requisite to form such large machines, he could not complete his intention before 1774. What intention could he not complete? The remainder of the sentence explains;—"when he finished "some large engines, as specimens of his construc- "tion, which have succeeded so as to demonstrate "the utility of the said invention." The patent is dated in 1769. Four months are allowed to enrol the specification: before this was complete, it were absurd to begin the erection of large engines, which must make public the invention. Considering the difficulty in training workmen, the expense of constructing large engines, and the other occupations of Mr. Watt, with the usual poverty of inventors, five years do not appear a very long period for completing some large engines, which by their effect had demonstrated the utility of this invention. Though all this appears on the face of the preamble to have been done in 1774, yet it is supposed the invention was not yet executed, because the legislature, speaking of future expected improvements, has these words: "It will "not be in the power of the said James Watt to "carry his invention into that complete execution "which he wishes, so as to render the same of the "highest utility to the public of which it is capable." These expectations of future utility to the public have been completely fulfilled. Mr. Watt, by his additions of the Parallel Motion, by his Centrifugal

Forces regulating the velocity of the engine, by his Planetary Wheel, by his various improvements in the Valves and Levers, has brought the whole complex apparatus to a degree of perfection, which the boldest imagination could hardly conceive, and which he himself scarcely dared to hope. A force more than double that of gunpowder, has been made to correspond in its movement with the pendulum of a clock; an effort of art which seems almost beyond the reach of human invention. These superadded parts have perfected the execution, and increased the public utility, of the first invention; but are in their nature altogether distinct from it. Some have been the objects of new patents,—all might have been; but this patent which we are now discussing was granted for the invention of making the steam act in a vessel kept always hot as steam itself, whereby none was condensed until it had performed its office, and condensing in a separate vessel kept always cold, whereby the condensation was perfect, and all sensible resistance to the motion of the piston removed. By this invention, the object of lessening the consumption of steam and fuel was complete and perfect. This invention cannot in the nature of things be carried further, because it is impossible to have more than all.

I have laboured, I hope successfully, to prove, that the Act of King James comprises all inventions within the whole circle of the arts; that Mr. Watt's invention falls far, very far indeed, within this boundary; that the specification correctly describes this invention; and, lastly, that the statute 15th

of the present King, has continued to Mr. Watt a longer term in the invention so specified.

It seems to me, however, that the verdict has precluded all these questions, and shut out every objection that is now insisted upon in this cause. To avoid all controversy about names, the declaration employs the general term *Invention*. I presume no objection can be urged to the use of a term which has been the term used in the granting clause of patents from the passing of the act of King James. The more peculiar name or designation of this invention, in the patent and specification, is a "Method of lessening the Consumption of Steam "and Fuel in Fire Engines.". If this designation wanted authority, we have a list of more than two hundred methods of doing things, for which patents have been granted within the present century; several of which have had the sanction of parliament, several of which have been confirmed by the judgment of courts of justice. Perhaps the method of doing something, or producing some specific result, is the correct designation of every invention; and that the mode of doing it is all that any inventor can teach. But however this may be, certain it is, that the name or designation in the patent never was intended to teach us what is the invention, or point at more than its general object; for an express condition is inserted in every patent, requiring the inventor at a future time, within four months from the date of the letters patent, "to "particularly describe the nature of his said inven- "tion, and in what manner the same ought to be

"performed." It is averred on this record, that such an instrument does sufficiently describe the invention in the very words of the condition. These facts are now conclusively found by the jury. We must now therefore look for the nature of the invention in this instrument or specification; and we there find that it is a combination of solid material parts, enclosing "the cylinder with wood to "keep it hot, removing the cold water before in "use, substituting the fat of animals in the place of "water to keep the piston air-tight, adding a sepa-"rate vessel, the condenser; and, lastly, extracting "the vapour with a pump." Will any man deny that the making and combining these parts must be some manner of manufacture,—I care not what,—give it what name you please, only concede to me that it must be made by hands,—all the rest is found by the verdict,—that the thing is new, was invented by Mr. Watt, and that his specification teaches us to make it? These facts the jury have established, and have also found that the defendants have pirated the invention by actually making the thing so invented. No manufacture is more than a combination of parts antecedently existing. The clothier does not make the wool, he only combines the parts: the silk-weaver does not make the silk, he only combines the parts. Surely these are manufactures. So our combination must be a manufacture; and if it be any manner of manufacture, the express words of the statute of James declare it may be the subject of a patent.

Nothing now remains but the continuing statute

of 15th of the present King. This statute refers to the patent by its date and description. This statute then recites, verbatim, the specification, prolongs the term, and then expressly provides that every objection competent in law against the patent shall be equally competent against the Act of Parliament, to all intents and purposes, except so far as relates to the term hereby granted. The legislature likewise, as if to obviate the present objection, expressly provides that "this Act shall not "be construed to restrain any person from making "or using any fire or steam engine, or any parti- "cular contrivance relating thereto, which is not "the invention of the said James Watt, and speci- "fied in this Act." All other engines and contrivances are secured to the public, as if this Act had never been made.

The Act, therefore, expressly refers to the specification, and secures to Mr. Watt, for twenty-five years, the invention found by the jury to be sufficiently described in this specification, so recited in the Act, and nothing more.

It were perfectly idle now to dispute whether the term "engines invented by Mr. Watt" do or do not properly describe the invention for which the patent was granted, when the legislature have told us positively that they mean this invention, specified under the patent, recited in the Act; and, negatively, that they mean nothing more.

If we remove some few ambiguities of language, it will be found that all the learned judges of the Court of Common Pleas concur in favour of my

client. Mr. Justice Heath expressly says, "It ap- "pears that the invention of the patentee is original, "and may be the subject of a patent." In fact it has been the subject of a patent, granting Mr. Watt the monopoly of his invention in the usual form. The statute of James requires nothing more, annexes no condition to the grant. It were indeed absurd to require a disclosure of the nature of the invention before the patent had actually passed; but a condition always inserted in the patent requires the patentee, at a future period, to "describe "the nature of his said invention, and how the "same is to be performed." That this has been done by Mr. Watt, is averred on the record, and found by the jury in the very words of the condition.

The learned judge admits the invention to be within the statute; "it might legally be the subject "of a patent." Will he then declare the patent void, for a supposed non-performance of a condition in direct opposition to the record? Whether the condition has been performed must be a pure question of fact. Did Mr. Watt secure to the public the future use of his invention? Did he teach by his specification others to make the thing invented? The jury have said he did, with the approbation of the judge who tried the cause; and that verdict stands unquestioned, even by the adverse party.

Mr. Justice Heath then proceeds, "If method "and machinery had been used by the patentee as "convertible terms, and the same consequences "would result from both, it might be too strong to

" say the inventor should lose the benefit of his " patent by the misapplication of his term." On this record the learned judge can know nothing of the invention but from the patent and specification, which now make one instrument. In the patent the invention is named a method; in the specification this method is described to consist of mechanical parts, which is plainly the sense in which Mr. J. Heath uses machinery. Are not, therefore, these convertible terms? The terms are affirmed of each other. Both terms express the means of saving steam and fuel in fire engines. The jury have found the fact that such is the result. That the same consequences not only would, but must equally result from both is evident; for both terms are, one general, the other minute, descriptions of the same thing.

There is no danger to the patentee from his misapplication of any term. His danger arises solely from a misapprehension of the nature of language by the learned judge. He plainly expects in the specification, in the description of a species, what belongs only to the individual. If I describe an individual man, he may be six feet high, and of a dark complexion; but if I describe the species, I must omit all that belongs only to the individual, and confine myself to the qualities which are essential to the species. Thus of lions, colour belongs to the species, because all lions are of one colour. In the same manner particular dimensions of the parts, may or may not be of the essence of an invention. In a specification, therefore, whose object is to teach

others to make, not an individual machine, but all machines of the same species, we must omit all that belongs exclusively to the individual, and confine our description to those qualities which are essential to the execution of the invention.

In the present instance, it would have been absurd to have given the dimensions of the wooden case which was to keep the cylinder hot. The coat must fit the body, and the carpenter must measure each individual cylinder. When the artist is told how to keep the cylinder as hot as steam,—how to remove the jet of cold water,—how to substitute the fat of animals for water on the piston; he is told all that belongs to this part of the invention. He can remove all bodies that tend to cool the cylinder; he can keep it hot by clothing. Whether all this, when done, will produce the effect intended, is and ever must be a pure question of fact.

Again, that the shape and size of the condenser cannot be material is evident. The condenser is intended to receive steam, which has no shape or form, and which is condensed, annihilated the moment it enters, and as it enters. To keep this condenser cold is the object. When therefore the artist is told that it must be kept cold by contact with cold bodies, all the rest depends on the local conveniences which the particular individual spot on which the engine is erected may afford. Accordingly, where a running stream is found, this condenser has been prolonged to forty or fifty feet, without any sensible inconvenience. The pump, to

extract the vapour, is sufficiently described by its name.

This apparatus, thus described, the jury have found will save steam and fuel in fire engines, or, in other words, is an effectual method of saving steam and fuel in fire engines,—the avowed object of the invention.

Upon his own data, therefore, Mr. Justice Heath ought to have given judgment in our favour. The same, I think, may be affirmed of Mr. Justice Buller.

He says, "The case states the plaintiffs' patent, "specification, and the Act of Parliament; it gives "a description of the old engine, and then it states "that the plaintiffs' is a new and useful invention, "and that the specification is sufficient to enable a "mechanic to construct fire engines, producing the "effect of lessening the consumption of fuel and "steam in fire engines, upon the principle invented "by Mr. Watt."

The learned judge reprobates as futile the objection, "that a patent could not be good for an addi-"tion or improvement;" and adopts the opinion of Lord Mansfield, "that this objection would go to "repel almost every patent that ever was granted."

The learned judge then declares it to be his judgment, that the patent was given for an engine; but he conceives the invention to be of an improvement, and therefore gives his judgment for the defendant.

I would ask the learned judge whence he collects the patent to be given for an engine? He must

read the description in the specification; for on this record he can have no other knowledge of the thing invented. I would then ask the learned judge, whence he collects the invention to be of an improvement? He must again read the same description in the specification; for he has none other on this record to give. It is plain, therefore, his terms engine and improvement represent the same complex idea,—the apparatus described in the specification.

Mr. Justice Buller then proceeds to observe that "the plaintiffs' counsel were forced to admit that "there was nothing new in the machine." If such an admission was ever made, the learned counsel forgot the nature of the thing invented,—forgot the verdict of the jury. Was not the covering of the cylinder new? Was not the removal of water from the cylinder new? Was not the substitution of the fat of animals new? Was not the condenser new? Was not the pump new? Was this combination, or any one part of it, ever before employed in the fire engine? I presume the learned judge used the term "new" in the sense in which it may be affirmed that there is nothing new under the sun,—nothing new since the Creation. God, indeed, alone creates, man can only combine: but, in the sense in which novelty can be affirmed of any of the works of man, every part of this apparatus is new, and must be taken to be new on this record.

The confusion in the Court of Common Pleas originated from a direct contradiction in terms, assumed in describing the invention of Mr. Watt. It

was proved, by irresistible evidence, that the specification was sufficient to enable an artist to construct the thing invented. The jury therefore found this fact. They also found that the defendant had pirated the invention, by constructing an engine similar and upon the same principle. It was forgotten, that to construct and organize were synonymous terms; and in direct contradiction to the verdict of the jury it was assumed, that what could be constructed, and actually was constructed, had no organization of parts. The confusion arising from this original error was greatly increased by an incorrect use of the words "method," "principles," "machine," "engine." "Method" is the French *méthode*, from the Greek μεθοδος, *via vel ratio aliquid agendi*. "Principle" is *principium*, source, operative cause, elementary or constituent parts. When Mr. Watt says in his specification, "my "method of lessening the consumption of steam "and fuel consists of the following principles,"—(describing the cylinder kept hot by enclosure, the fat of animals applied to the piston, the separate condenser and pump),—he in other words affirms, that the particulars so described are the constituent parts of his method or manner of attaining the end proposed. When, again, we speak of these particulars with relation to the effect produced, then principle means operative cause; and the proposition is, that these particulars are the operative cause of, or do produce the effect of saving steam and fuel. The word "machine" is the Italian and Latin *machina*, from the Greek μηχανη, *ars*,

solertia. "Engine" is the French *engien;* the Latin *ingenium.* Both terms therefore, in their original sense, signify invention, contrivance; and, by a metaphor common to all languages, (cause for effect), are used for the thing contrived or invented. Thus the particulars described may be said to be the principles or constituent parts of the machine, or engine, or thing contrived by Mr. Watt to lessen the consumption of steam and fuel in fire engines. Here again the term engine, in the last part of the sentence, is used in a larger sense, comprising all fire engines of every description.

These words, "machine," "engine," are capable of two other senses, somewhat varying from those already defined. By another metaphor, (*pars pro toto*), we say Savery's engine, Newcomen's engine, Watt's engine; meaning the engines having severally the peculiar character of their respective inventions, though we are conscious that each of these contains not only the peculiar invention of the person named, but likewise other parts which were the inventions of other men before those persons were born. The remaining sense of these words is the most abstract use of the terms; here machine or engine will comprise, not merely contrivances of this or that particular description, but every instrument, simple or complex, which bears the character of invention and contrivance. Whoever, overlooking the various application of these terms, assumes that, because he uses the same word, he always expresses the same idea, will easily reach conclusions which have no foundation in truth.

Neglecting, therefore, all verbal ambiguities, your Lordships will examine the reality of things; you will then find that Mr. Watt has invented an engine of most powerful effect, the constituent parts of which are correctly described in his specification. The conclusion will necessarily be, that Mr. Watt, having performed his part of the contract with the public, by enabling others to execute his invention at the expiration of the term of years granted to him by the public, must, upon every principle of justice, be entitled to enjoy the sole right of making and selling his invention until that term of years shall expire. I humbly therefore demand the judgment of the Court in favour of my clients.

No. VII.

OPINIONS OF THE JUDGES IN THE COURT OF KING'S BENCH, ON THE PROCEEDINGS IN ERROR IN THE CAUSE BOULTON AND WATT *versus* HORNBLOWER AND MABERLY; HILARY TERM, 1799.*

HILARY TERM, 59 GEO. III. B. R. 1799.

Lord KENYON, *Chief Justice.*
Sir WM. HENRY ASHHURST,
Sir NASH GROVE,
Sir SOULDEN LAWRENCE,
} *Justices.*

MR. SERJEANT LE BLANC having argued this writ of error for the plaintiffs, and Mr. Rous for the defendants, the Court immediately gave judgment as follows:—

LORD KENYON, C. J.—When this action was commenced, I do not know; it appears that the opinion which has been adverted to in the Common Pleas was given in the year 1795. It was argued the last term in this Court for the first time, and we have gone on as rapidly as we could with a proper attention to the business of the Court; because, where two learned judges have differed in their opinion from two others, it would be rash in us to decide the point without having it very fully discussed. It was for that reason, and not because it

* From notes taken in short-hand by Mr. Gurney, and originally published in 1799.

was not extremely well argued the last term,* that the Court directed a second argument. It has been now sifted to the bran; everything has been said that can be brought to bear upon the point; and I am inclined to give my opinion at once.

The patent, we are told, is within a few months of expiring; the costs therefore are the great object the parties have in view in obtaining this judgment.

I am one of those that have not been a great favourer of patents, because, though in many instances, and in this peculiarly, infinite benefit has been derived to the country; yet upon casting up the whole, I think they have occasioned great inconvenience to the public, and a great deal of oppression on the lower orders of mechanics .... on the part of those who have obtained patents, and are more opulent.

If the decision of this cause required either any mechanical knowledge or metaphysical learning, I should disclaim anything of the kind; and I should be very unequal to give a judgment in the place in which I sit. I never understood the famous author of the Minute Philosopher's works: they were doubtless intended for good purposes. I never understood the works of another philosopher, whose object perhaps was not so beneficial to mankind; but I do subscribe to what Dr. Beattie, in his treatise on the Nature and Immutability of Truth, said in answer to those gentlemen who had

* By Mr. Gaselee for the plaintiffs in error, and by Mr. Holroyd for the defendants.

denied the existence of matter, when he advised those philosophers to go to the edge of some precipice, as the cliffs of Dover, for instance, and throw themselves down: he thought at the end of their journey they would probably find there was some matter, and dash their bones to pieces or their brains out.

One is not to be surprised that in the course of an argument of this kind a counsel should omit some circumstance. Mr. Rous was challenged to say whether all the counsel had not, in their several turns, as this cause went through all its stages, whether the counsel had not said that the patent was for a philosophical principle, and not for anything organized: he said he would give a direct answer to it, and I understood him to deny it, though he did not take it up expressly in terms. I understood him to argue all along that this was not for a principle, but for something organized.

I shall not consume many minutes in expressing my idea of it. My Lord Hardwicke once said, "there is no magic in words." I look at the whole of this patent and the specification, incorporating them together, to see whether this is or is not a patent for a manufacture; and if it is a patent for a manufacture, then whether it is sufficiently described for any manufacturer to make it. The jury have not in express terms said so, but they have impliedly said so, as Mr. Rous has observed, or they could not have found a verdict for the plaintiff. Really, having said this, I might almost say "*dixi*:" for I do not know what I have to say more.

The question is, whether this Act, explained, as it goes on, by this specification, has not said that the monopoly which this gentleman claims is for an engine, a machine, or whatever you will call it, composed of material parts, which are to produce such an effect, and that it is so described in the specification as to enable any workman who looks at it to do the thing meant to be done. It is not material whether the condenser shall be circular, square, octagon, decagon, or what shape it shall be; neither is form material in the steam case; it is only to be a kind of an outside fabric surrounding the cylinder, and is to be formed of wood, and the insterstices to be filled up and made air-tight in order to produce this effect.

I have the greatest respect for opinions which have been entertained differently: if I had been called upon suddenly, without hearing this discussion, to say whether this was all right or not, I should probably have been in a wood: but, applying what I have learned from the bar and other quarters to this case, I cannot forbear saying that I have not the least particle of a doubt that this is a patent for a manufacture, and for something to be made by the hand of man, of such materials, and to produce such an effect. I am clearly of that opinion, and therefore of opinion that this judgment ought to be affirmed.

ASHHURST, J.—I entirely concur in what my Lord has said. I think the encouragement of new inventions of infinite importance to the kingdom; and, when it appears incontestable that the inven-

tion does possess all the useful properties that this professes to do, it would be very hard if the inventor should be robbed of his reward by a frivolous criticism, when the public are actually enjoying from the fruits of his labour the most solid advantage. The jury have by their verdict given their assent to all the facts stated in the declaration. There was another thing that was only introduced, I believe, by way of evidence, that a person in a distant country, who was conversant with the subject of fire engines, made a drawing of a complete engine, properly organized, merely from the information that this specification gave: if he did, why, then the patentee has done everything that he pledged himself to the public to do, and the public, in consequence of that, now enjoy the fruits of his labour: therefore, that being the case, I am for giving every encouragement to it: and, as to any little deviation in point of form, I own I should be rather disposed to give some candid allowance to it. I think in point of justice he has every title in the world to it; neither do I see that there is any circumstance so glaringly opposite to the policy of the law; none indeed to the policy, whatever there may be by verbal criticism: but he has in general substantially complied with everything the law requires of him, and therefore, for these reasons, I am willing to concur with his Lordship in the judgment he has given.

GROSE, J.—This action is for violating a patent granted so long ago as the year 1769, the benefit of which was continued to Mr. Watt, his represen-

tatives and assigns, for twenty-five years, by a statute made in the year 1775. The statute recites the patent. The benefit of the patent is now determined by a lapse of time, and therefore the action can only be sustained on the continuance of that patent by the Act of Parliament I mentioned. The statute expressly provides that every objection in law competent against the patent shall be competent against the statute, in case the patent ought not to have been granted.

The question then comes to this, whether the patent be good in law, that is, whether it is conformable to the statute of James I., under which the plaintiff, and indeed any party, must claim privilege of a monopoly? The power reserved to the King is, that any declaration before-mentioned shall not extend to any letters patent, and grants of privilege, for the term of fourteen years or under, heretofore made, of the sole working or making of any manner of new manufacture within this realm, to the first and true inventor or inventors of such manufactures, which others, at the time of the making of such letters patents and grants, did not use. These are the terms upon which the patent is to be good;—"so they are not contrary to the law, "nor mischievous to the State, by raising the prices "of the commodities at home, or hurt of trade, or "generally inconvenient." If they comply with all these requisites, then the King has a power to grant such a patent.

The questions then are, whether this is a patent for the sole working or making of any new manufac-

ture? whether the patentee was the first inventor; and whether it is contrary to law, mischievous to trade, or generally inconvenient? By a proviso in the patent, the patentee is bound particularly to describe and ascertain the nature of his invention, and in what manner the same is to be performed, by an instrument in writing under his hand and seal, and cause the same to be enrolled in the Court of Chancery within four months. Then arises another question, which I observe was agitated upon the argument in the Common Pleas, namely, whether this specification was sufficient?

Now the aim of the legislature in this Act of Parliament, and in the statute of James I., is, obviously, to encourage ingenious artificers and studious men to bring forward, for the use of the public, new manufactures, the produce of their own invention; and this was to be done by holding out to them a reward, which otherwise would be illegal, —a fourteen years' monopoly;—and they meant to secure to the public the benefit of these men's ingenuity, by obliging them to enroll a sufficient description of the invention, that others might, at the expiration of fourteen years, be enabled to make and use the same invention.

Upon some of these questions that I have mentioned it seems to me there cannot possibly be any doubt. There is no doubt upon this record, from the finding of the jury, that the patentee was the inventor of this, call it invention, method, engine, manufacture, or what you will, stated in the declaration; for he is found to be the inventor. It is not

contended that the subject of the patent is contrary to law, or mischievous to the state, by raising of the prices of commodities at home, or hurtful to trade, or generally inconvenient. On the contrary, every man's experience tells him that the invention has infinite merit; that it is for very many purposes highly beneficial to the public, and is known to be in great request from one end of the kingdom to the other, from the north to the west. In the west, I know, a great deal of money has been got by the effect of this patent, and a great deal has been got by persons who have bought it; so useful is it to the patentee and to the public.

As to the specification, I shall content myself with repeating what was said by one of the learned judges in the Common Pleas; that if it is such as will enable an artist to make the manufacture, or adopt the invention, it is sufficient. Now it is averred in this declaration that the patentee did, in pursuance of the proviso, particularly describe and ascertain the nature of the invention, and in what manner the same is to be performed; that fact upon the record was necessary to be proved, to entitle the plaintiff to a verdict: the plaintiff has a verdict upon that averment; therefore I consider that fact ascertained and concluded in his favour.

The important question is, whether it is a patent for a new manufacture? It is argued by the plaintiff in error, first, that it is a patent for a principle, and not for a manufacture; secondly, that if it is a patent for the manufacture of a steam-engine, it is not new; and that the patent, (for so it was stated

before), should have been for the addition only, and not for the whole.

As to the proposition insisted upon by the plaintiff in error, that upon this statute there cannot be a patent for a mere principle, in my way of considering the question, it is not necessary for me to form a decided opinion upon that; for if I can show that this is a patent for a new manufacture, whether a patent for a mere principle is good will not be material. Upon this point I shall only say, that, having much turned that question in my own mind, and weighed it, (I think the words upon which this question must depend, I mean the words which specify what patents the Crown may grant, are that the Crown may grant patents of the sole working and making of any manner of new manufactures), I am not prepared to say that a patent for a mere principle was intended to be comprehended within these words. It is difficult to conceive that the legislature intended a power to grant a patent other than that of working and making a new manufacture; but I say that is not at present material, as it appears to me; for, considering the case in the best way I am able to consider it, I have no difficulty to pronounce that this is not a patent for a mere principle, but for working and making a new manufacture within the words of the statute. I have been led to this conclusion, by considering the words of the patent as referred to and explained by the specification, and considering the specification as part of the patent. The ground upon which I have felt myself at liberty to do this,

is from the specification disclosing to the world how others may make and use the same manufacture; without this specification the world would not have that information; and, by the letters patent without the specification, the patentee is not entitled to his monopoly; it is provided, therefore, that there must be a specification, and, there being necessarily one in consequence of that proviso, I consider the patent and specification as so connected together as to make the one a part of the other; and that, in order to learn what the patent is, I am to consider the specification as incorporated in the patent. I conceive myself at liberty, by law, to consider the patent and specification together.

The patent recites that Mr. Watt has invented a method of lessening the consumption of steam, and consequently of fuel, in fire engines; and it grants him the sole use and exercise of that invention, upon condition that he should disclose the nature of his invention, and in what manner the same was to be performed, by an instrument enrolled in Chancery. He does so, and that instrument describes, as I conceive, the principles of the method, and the method by which those principles are to be carried into effect. The method is founded upon the principle of keeping the steam-vessel, the whole time the engine is at work, as hot as the steam that enters it: this is to be done by enclosing it in a case of wood, or some other material that transmits heat slowly; by surrounding it with steam or other heated bodies; and by suffering neither water, nor any other substance colder than the steam, to

touch it. The specification next points out the mode of condensing the steam by vessels, which are to be distinct from the steam-vessels sometimes, at other times to communicate with them; these vessels are called condensers, and they certainly are part of that invention which this gentleman now offers to the world; they are to be kept as cold as the air in the neighbourhood of the engine. The third direction he gives is, as to the drawing out the air which is not condensed by the cold of the condensers. Fourthly, he states how he means to employ the steam to press on the piston, in given cases. Fifthly, he describes how the steam-vessels should be formed, where rotatory motions round an axis are required; how the steam-vessel should be supplied with steam; and how that which has done its office should be discharged; and he states a method by which the engine may be worked, by what Mr. Rous strongly observed upon, the alternate expansion and contraction of the steam: now if this method is not effected, or accompanied, by a manufacture, I admit I should hardly consider it as within the statute.

By this specification it seems to me that he does completely describe a new manufacture by which his principle is realized; that is, by which his steam-vessel is kept as hot as the engine, by which means the consumption of steam and fuel is lessened. He describes the case of wood in which it is enclosed; he shows how the engine is to be worked, wholly or partially, by the condensation of steam; and he likewise mentions what is necessary

in cases where a rotatory motion is required. Now, looking at all this, I can only put the question in the way Mr. Rous has put it, whether any man can deny that the making and combining these parts is not some manner of new manufacture; and the answer is, they cannot find,—and it seems to me I cannot find,—any principle, any ground, any argument, upon which any man of sense or intellect can possibly deny it: that does seem so to me.

But, as a patent for an engine, it has been objected that this engine was made before, and that this patent should be for the addition. Though I consider it as a patent for an engine, I do not consider it as a patent for the old engine, but consider it as a patent for an addition to or improvement of that old engine; and so, by and by, we shall find the Act which was obtained in the year 1775 considers it, upon the words which my brother Le Blanc mentioned, but which, I think, he and I must put different interpretations upon.

The old engine, it is to be observed, consumed too much fuel, and Mr. Watt conceived that by enclosing the steam-vessel in a case of wood, or other materials that would transmit heat slowly,—that by surrounding it with steam or other heated bodies, the defects in the old engine might possibly be cured, and the new one by his additions made more useful. A patent was obtained, and the invention was tried; but it did not at first answer so as to become profitable, and for that reason it was necessary to get an Act of Parliament. Now, upon that patent, if it was for the whole machine it might be

carped at, and therefore the patent has been obtained in the words in which it has;—not for an engine, but for an invention of a method of lessening the consumption of steam, and consequently of fuel, in fire engines. Now that very method is disclosed in the specification, that method is by the addition of what is there described: the patent is, therefore, for that additional improvement as described in the specification: there is no pretence, in my opinion, to say that the patentee claims the sole making of the old engine; he claims only the making of the new engine, improved and described as it is.

A doubt has been expressed, whether, in point of law, there can be a patent for an addition to an old engine? I consider this certainly as a patent for an addition to the old engine, and, when that addition is made, constituting a new engine. Now this doubt is raised merely upon the authority of Bircot's case, in Lord Coke, 3 Inst. 184. I have examined as far as I could into that case; but, from what I have been able to find upon that subject, I can only answer that argument in the way it was answered by two learned judges in the Common Pleas, by my brother Buller and my Lord Chief Justice. My brother Buller cited Bircot's case, which was decided in the Exchequer, and the case of Morris *v.* Branson, where the patent was for making oilet-holes, in which Lord Mansfield held that the patent was good; and he says that since that time it has been the generally received opinion in Westminster-hall, that a patent for an addition is good. I

perfectly agree in that, and I think that, if patents for additions to old manufactures cannot under this statute be made, it would be robbing the public of one of the best consequences of this statute. It does seem, therefore, that the idea of Lord Coke was thrown out hastily, without due consideration; and when we recollect what has passed since that time, everybody will see, that the idea of modern times is, that a patent may be granted for such an addition.

The statute of the fifteenth of the present King secures to Mr. Watt the privilege of constructing and selling these engines; but upon that statute my brother Le Blanc has to-day made an observation, as if it was to be imputed to the framer of that statute that he had falsely recited the grant from the crown, that it gave him the power of making and vending certain engines, meaning the old engine; but that is not so; it is that his Majesty "did give and grant unto James Watt the "sole benefit and advantage of making and vend-"ing certain engines, by him invented, for lessening "the consumption of steam and fuel in fire en-"gines." Why, then the engine invented is for the purpose merely of lessening the consumption of steam and fuel in an engine which he did not pretend to be his engine, or to be a new engine, or an engine which he claims any right to, but he considers it as an engine in use and known to the world. When the objection is made upon this last Act, I say that statute must have a reasonable construction; it must have a construction which will rather support

than defeat the intention of the legislature, and of their grant made by this statute, for I consider this Act as a grant by the legislature; and it is obvious to me that the engines secured to Mr. Watt are the engines so improved as stated in his specification, and not the original fire engine, for the statute recites the patent as a grant of the benefit and advantage of making and vending certain engines, by him invented, for lessening the consumption of steam and fuel in fire engines: now these engines were not the original fire engines, but the improved engines; and these engines, so improved, were the only ones invented for lessening the consumption of steam and fuel in fire engines. This shows that the legislature considered the patent as for an improved engine, and not as a patent for a mere method, or for the original fire engine. I have no difficulty to confess and say that the subject was very new to me, and that considerable difficulties had occurred to me in making up my mind upon it. As I do not affect to have any considerable mechanical skill, in considering of one proposition which has been debated, I have no difficulty in saying I am of opinion that a patent cannot be granted for a mere principle; for, though the privilege in the patent is for the exercise of a method of doing anything, if that is to be done by a manufacture, and the method of making that manufacture is described, it then becomes not a patent for a mere principle, but a patent for the very thing described in the Act of Parliament, namely, a manner of new manufacture: and where

is the mischief to the public, or how is the intent of the legislature defeated? The legislature intended that, after fourteen years, the public should be in possession of the manufacture and the art, and that the patentee should have the benefit of the monopoly for fourteen years. The patent is nothing without the specification: it is useless unless the public has this information: whether the patent calls the manufacture by its name, or styles it a method or mode of doing the thing, signifies nothing; for the specification must be resorted to; and, as I said before, may be deemed a part of the patent. When I look at the patent, I see it is for a method of lessening the consumption of steam and fuel in fire engines; I look at the specification, and there I see a manufacture, and in the way in which the public is to have the benefit: the intention of the legislature is fulfilled; the public will enjoy the fruits of the author's ingenuity, and the author in return has the benefit of his monopoly. It signifies nothing what the patent is for, whether for one or for the other, if the method be described in the specification. Upon these grounds, with that sort of deference which I ought to pay to the opinion of others who think differently upon the subject, it is my humble opinion that the judgment of the court below ought to be affirmed.

LAWRENCE, J.—In this case there are two objections: first, that this is not a patent for an organized machine, but for philosophical principles only; secondly, that, supposing the patent is for some engine, the specification is bad. The claim of the

plaintiff in this case is founded upon that proviso in the statute of James, which allows the Crown to grant a patent in favour of new manufactures: that, therefore, which is the subject of a patent, must be a new manufacture. If it were necessary to consider upon this occasion whether a patent could be granted for mere abstract principles, I should have great difficulty to say I could think this a new manufacture: but if we attend to the recital in the Act of Parliament, it appears that Mr. Watt did apply for and obtain a patent for an engine, or mechanical contrivance, for lessening the consumption of steam and fuel in fire engines. The letters patent recite that Mr. Watt had invented a method of lessening the consumption of steam and fuel in fire engines, and his Majesty grants to him the sole right of using his invention for fourteen years. To see what that invention is, we must refer to the specification, which recites that the method consists in what he calls certain principles, which principles are stated in the specification. Then the statute of the 15th of the King recites, that the plaintiff had had granted to him the sole benefit and advantage of making and vending certain engines, by him invented, for lessening the consumption of steam and fuel in fire engines, and it vests in him the sole right and benefit of vending the same for twenty-five years. You see the statute recites the specification for that which it calls an engine, which there is called a certain principle.

Now it seems to me, that in this case it is evident the legislature understood that the patent

was for some mechanical contrivance, and I do not think the terms in the specification and the Act are contradictory; manufacture, engine, and method, seem to me to mean the same thing; a method is used to signify an engine, though perhaps not in a very proper sense: but, in discussing a question of this sort, it is not to be decided by a criticism upon the language which mechanics use. A method, properly speaking, is the doing and performing an operation in the best and most convenient way. I think a mechanical contrivance and device may be said to be a device; and therefore, I think, that may likewise be signified by the word method; so principle may, in the sense that I put upon it as mere elementary truths, be applicable to this: but principles may mean constituent parts. Then what is the meaning of this? "My method of lessening "the consumption of steam and fuel in fire engines "consists of these constituent parts." That seems the substance of the specification. The whole of it is this:—My contrivance, by which I lessen the consumption of steam, and consequently fuel, in fire engines, consists of these elementary parts: the steam vessel must, during the whole time the engine is at work, be kept as hot as the steam that enters it: first, by enclosing it in a case of wood, or any other material that transmits heat slowly; secondly, by surrounding it with steam or other heated bodies; and thirdly, by suffering neither water, or any other substance colder than the steam, to enter or touch it during that time; having a distinct vessel to condense the steam in,

and pumps to draw off such vapour as is likely to impede the motion of the engine.

Now, considering this as a patent for an engine, it is objected that the specification is bad. In order to decide whether it is bad or not, we should look a little, and see what it is Mr. Watt obtained his patent for; what he claims is not an improvement on any particular fire engine; is not the application of the fire engine to working a pump, raising water out of a mine, or turning a mill; but it is an invention to lessen the consumption of steam and fuel in fire engines: in short, his claim is of an invention applicable to all fire engines, whatever purpose they may be used for, and whatever may be their constructions; and that, by the alteration of some parts, and addition of some parts which are common to all fire engines. The objection that more ought to be stated, in order to have a complete specification, must go the length of saying this: that he ought to have described in his patent every engine that is worked by the power of steam; he must not only describe the engine by which pumps are worked, but mills, &c., in order to entitle himself. I think Mr. Watt could not have had a patent to that extent; because, if he had so claimed it, he would have claimed a patent infinitely beyond his invention; that being so, the patent must, I conceive, be supported as granted for an improvement of, and as an addition to, the old engines known and in use; and it does seem to me, that the patent is good in this point of view, for it claims no right whatever to the construction

of engines for any determinate object, excepting for the purpose of lessening the consumption of steam and fuel in fire engines: he claims a right to engines applicable to that distinct purpose, and no other. The plaintiff's contrivance, method, or engine, (they all mean the same thing), is for lessening the consumption of steam and fuel in such pre-existing old machine: I think some of the difficulties of this case have arisen from taking the word engine in its popular sense: I think it may have a further meaning, and may signify any mechanical human device; and I think that is clear from the use of the words engine and method as convertible terms: I think that was the understanding of the defendant in error; and I conceive that there can be no question but for such a contrivance a patent may be granted, as much as for more complicated machines or engines; that it would equally fall within the description of a manufacture; and, unless that be so, all patents granted for improvements and additions would be void.

If that is so, then the only thing remaining to be considered is, whether for the improvement in fire engines, by lessening the consumption of steam and fuel in fire engines, the plaintiff has sufficiently stated the definite alteration and improvement, so as that it may be made by any workman. It seems to me he has: he has directed them to condense the steam in vessels distinct from the steam vessels, although occasionally communicating with them; he then directs them to keep the steam vessel as hot as they can, by surrounding it by a case of

wood, or any other material that transmits heat slowly: he has directed that, instead of water, to render the piston or other parts of the engine air and steam tight, they should use that which will not cool the engine; and he has directed pumps to be used, for the purpose of exhausting the vapour which is not drawn out any other way: whether the directions which he has given are sufficient for the purpose, is not a question now before us; that has been decided by the jury. I agree the judgment must be affirmed.

LORD KENYON.—I rather think it would be difficult to form a specification of a philosophical principle; it would be something like an idea without a substratum.

Judgment affirmed.

No. VIII.

SUPPLEMENT TO THE OPINIONS OF THE JUDGES IN THE CAUSES BOULTON AND WATT *versus* BULL, 16TH MAY, 1795; AND BOULTON AND WATT *versus* HORNBLOWER AND MABERLY, HILARY TERM, 1799.

(No. 1.)

The DECLARATION in the Cause BOULTON and WATT *v.* BULL, contains the following Counts:—

1. For *making*, *constructing*, and *selling* engines in imitation of the engine invented and found out by the plaintiff James Watt, and secured to him and his assigns, for the term of twenty-five years, by the Act of Parliament therein set forth, and of the like nature and kind as the said kind of engine invented by the said James, in breach of the said Act of Parliament, and against the privilege granted to the said James as aforesaid.
2. For *making* and *constructing*, (omitting *selling*), as in the first Count.
3. For making, constructing, and selling engines *partly* in imitation as aforesaid.
4. For making and constructing, (omitting *selling*), engines *partly* in imitation, &c.
5. For *using* and *putting in practice the invention* attained to by the said James, and mentioned in the said Act of Parliament.
6. For *using* and *putting in practice part* of the said *invention*, &c.
7. For *counterfeiting* the said *invention*, and using and

putting in practice certain engines counterfeiting the said engine mentioned in the said Act of Parliament.

8. For *imitating* the said invention, &c.
9. For *resembling* the said invention, &c.
10. For *counterfeiting in part* the said invention, and using and putting in practice certain engines in part counterfeiting the said engines, &c.
11. For *imitating in part* the said invention, &c.
12. For *resembling in part* the said invention, &c.

(No. 2.)

MR. DOLLOND'S SPECIFICATION of his New Method of making the Object-Glasses of Refracting Telescopes.

To all to whom these presents shall come, I John Dollond of the parish of Saint Martin in the Fields in the county of Middlesex, Optician, send greeting: Whereas his most excellent Majesty King George the Second, by his Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the nineteenth day of April, in the thirty-first year of his reign, did give and grant unto me the said John Dollond his especial licence that I the said John Dollond, during the term of years therein expressed, should and lawfully might use, exercise, and vend, within England, Wales, and the town of Berwick-upon-Tweed, my invention of "A New Method of making the Object-Glasses of Refracting "Telescopes by compounding mediums of different refractive "qualities, whereby the errors arising from the different "refrangibility of light, as well as those which are produced "by the spherical surfaces of the Glasses, are perfectly cor-"rected:" In which said Letters Patent there is contained a proviso, obliging me, the said John Dollond, under my hand and seal, to cause a particular description of the nature of the said invention, and how the same is to be performed, to be inrolled in his Majesty's High Court of Chancery, within

three Calendar months after the date of the said recited Letters Patent, as in and by the same, (relation being thereunto had), may more fully and at-large appear. Now know ye, that, in compliance with the said proviso, I the said John Dollond do hereby declare, that my said new method of making the object-glasses of refracting telescopes, is to be performed in the manner following: (that is to say), The principal glass of a refracting telescope is that which is farthest from the eye, and is commonly called the object-glass, because it is at that end of the telescope which is directed toward the object. This glass refracts the rays which proceed from the object, in such a manner as to form an image of the aforesaid object in the focus, which image is magnified by the eye-glasses; but, as every ray of light consists of parts that differ in their degrees of refrangibility, an image formed by refraction is thereby rendered very defective, as all opticians very well know. Now, in these new telescopes, the images of objects are formed by the difference between two contrary refractions, the object-glass being a compound of two or more glasses put close together, whereof one is concave and the other convex. The excess of refraction, by which the image is formed, is in the convex-glass, which is made of a medium or substance in which the difference of refrangibility is not so great as in the substance which the concave is made of; therefore, their refractions being proportioned to their difference of refrangibility, there remains a difference of refraction by which the image is formed, without any difference of refrangibility to disturb the vision. The radii of the surfaces of each of these glasses are likewise so proportioned, as to make the aberrations or errors, which proceed from the spherical surfaces of these glasses respectively, equal; and, being contrary, they destroy each other. In witness whereof, I the said John Dollond have hereunto set my hand and seal, this twenty-third day of May one thousand seven hundred and fifty-eight.—John Dollond (L.S.) Sealed and delivered by the above-named John Dollond, (being first

duly stamped), in the presence of Jno. Clarke.—Acknowledged by the said John Dollond, the twenty-third of May one thousand seven hundred and fifty-eight, before me, W. Spicer. Inrolled in the office of Petty Bag, in his Majesty's High Court of Chancery, the twenty-fifth day of May, in the thirty-first year of the reign of King George the Second, by Richard Assheton, senior clerk of the Petty Bag.

(No. 3.)

Mr. Hartley's Specification of his Invention of "a "Method, by him invented, of securing Buildings against "the Calamities of Fire."

My invention of a particular method of securing buildings and ships against the calamities of fire is described in the manner following: (that is to say,) "By the application of "plates of metal and wire varnished or unvarnished, to the "several parts of buildings and ships, so as to prevent the "access of fire and the current of air, securing the several "joints, by doubling, overlapping, soldering, rivetting, or in "any other manner closing them up, nailing, screwing, sewing, "or in any other manner fastening the said plates of metal "into and about the several parts of buildings and ships, as "the case may require."

Extracted from the Act of Parliament,
17 Geo. III. c. 6.

(No. 4.)

A LIST of Sundry PATENTS, from 1693 to 1798, chiefly relating to Methods, Ways, and Means, with some few for Arts, shewing that such Patents were considered as Legal in the Opinion of the following great Lawyers, among others; namely LORD SOMERS, LORD COWPER, LORD HARDWICKE, LORD NORTHINGTON, LORD CAMDEN, &c., as Lord Chancellors; and LORD MANSFIELD, LORD WALSINGHAM, and LORD KENYON, and others, when Attorneys or Solicitors General; and LORD THURLOW and LORD LOUGHBOROUGH, the former as Attorney General and Chancellor, and the latter as Solicitor General and Chancellor.

A.D.

1693. A method of scouring in creeks, channels, &c., under water, from sand, mud, &c.—*John Poyntz.*

A way to separate flour, meal, &c., by wire screens, as also dressing powders, seeds, straining of sugar, &c.—*Thomas Neale.*

A new way of making salt.—*Thomas Bennett.*

A way to extract pitch, tar, and oil out of a sort of stone.—*Martin Eele.*

The art of making black silk crape.—*Francis Ponset.*

1694. The art of working iron into black latten and iron plates.—*Samuel Daviss.*

1695. A new way of smelting, sinking, and refining of pig or other cast iron, by pit coal or sea coal, or with peat or turf, into blooms and bars of iron.—*Thomas Chells.*

1697. A new way of making potash useful in tanning leather without the use of bark.—*John Cowland—Francis Barber.*

A.D.

1697. Art of making black and white silk crape.—*Robert Lydall.*

A new way to make potash from a certain wood or plant for making soap.—*John Cowland.*

1698. The way of making of the purging waters fine salt. —*Nehemiah Grew, M.D.*

The art of making black and white silk crape.—*Francis Ponset.*

1705. Method of refining salt from sea-water, and of making rock-salt by a reverberatory furnace.—*Daniel Peck.*

1708. Method of preparing green oil.—*Robert Pease.*

1729. Method of applying the centrifugal force of a body, &c.—*Francis Hawkesbee.*

1744. A way to make bay-salt by the heat of the sun only.—*Andrew Reid.*

1745. A method of preparing canvas to prevent the penetration of water.—*John Pitt.*

1747. A method of improving British spirits.—*William Mundee.*

A method of preparing clothes to be dyed scarlet. —*Onesiphorus Paul.*

A new method of making cartridge-paper.—*Josias Johannot.*

1748. A method of preparing cloth and hats to keep out rain.—*Joshua Wheeler.*

1749. Method of making pearlashes.—*Daniel Jervis* and *William Lodge.*

A method of making tarrass.—*Isaac Dent.*

A new method of making china ware.—*Thomas Frye.*

1750. A method of making Geneva.—*Osmond Cooke.*

1754. A new method of making saltpetre.—*Paul Nightingale.*

A.D.

1755. A new method of making wood into charcoal.—*William Blenncrhasset.*

1756. A method of manufacturing salt.—*Charles Ard.*

1757. A new method of casting guns or cannons.—*Isaac Wilkinson.*

A method of manufacturing red transparent glass.—*Mayer Oppenheim.*

1759. A method of impressing, in imitation of engraving, upon varnish laid upon copper, &c.—*Stephen Bedford.*

New methods in all sorts of malleable metal for polishing and colling in different forms, and making of tyre for wheel-carriages.—*Thomas Blockley.*

New method of making pots and building furnaces for making plate, green, and crown glass.—*William Richards.*

A method, entirely new, for raising water.—*Henry Hollaway.*

A method of taking wool from sheep-skins.—*Christopher Lebricht Chrysel.*

1760. The art of making isinglass from British materials.—*Humphry Jackson.*

A method of weaving ribbons, figured and flowered silk.—*Joseph Hill.*

A method of raising water out of mines, &c.—*John Barber.*

A method or machine to work boiling liquids, and bringing them to a proper consistence for working salt from salt water, &c., when dissolved, copperas, making saltpetre, and working spirits, sooner than are practised.—*Benjamin Price.*

1762. A new method of gilding marble and coloured paper.—*Henry Houseman.*

A way of making malleable iron from pig or sow metal without the use of charcoal, &c., but only with raw pit coal.—*John Roebuck, M.D.*

A.D.

1762. A new method of working and manufacturing salt. —*William White.*

A method of weaving cloth of linen, thread, silk, or worsted, in imitation of women's stitched stays.—*George Glasgow.*

1763. A new method of painting silks and satins in oil-colours.—*John Temped Christian.*

The art of making tarrass.—*Thomas Manlove.*

1764. A method of making salt of like quality, &c., of bay-salt imported from France and Spain.—*John Baker.*

A new method of making allum from liquid made from copperas materials, and uncalcined ore.—*Peter Holmes* and *three others.*

1765. A method of making fine, thin, and light cloth of wool and silk.—*Richard Williams.*

1766. A method of forming statues, &c., having the effect of the hardest stone.—*Dennis M'Carthy.*

A new method of constructing sugar-mills.—*John Greenhill Yonge.*

A new method of raising water out of mines and ships.—*John Barber.*

Method of making porcelain.—*Count de Lauragnais.*

1767. Means of making kelp by burning the sea-weed wet from the rocks.—*Thomas Delavall.*

1768. A method of making ink into a cake or solid body. —*John Dring.*

A method of making a silk stuff equal in goodness to Italian tiffany and crape.—*James Crookshank.*

A method of smelting gold and silver, &c., its ores, —*Robert Albion Cox.*

A method of milling raw hides and skins to answer the purpose of tanning.—*George Marchant.*

1769. A method of manufacturing black-lead crucibles. —*Gouse Bennin.*

A.D.

1769. A new method of making soap without boiling.—*James Auriol.*

Method of hatching birds by an artificial heat.—*John Champion, jun.*

A new method of chasing.—*John Pickering.*

A method of throwing silk to make crape and tiffany, and an engine to dress such silk when thrown. —*John Crumpler.*

1770. A method of dying card-paper and white leather of various colours.—*Charles Fearne.*

A method of tinning copper work.—*Maurice Crawford.*

Method of making opaque or transparent garnet or red glass.—*Mayer Oppenheim.*

A new method of refining spermaceti.—*Dl. Bridges, M.D.*

Method of tanning leather by making use of souring.—*John Johnson.*

A method of dyeing paper, card-paper, and white leather, on the grain side, of various colours.—*Charles Fearne* and *James Gray.*

1771. A method of making roasted coffee into a cake.—*John Dring.*

1772. Method of adjusting the glasses and otherwise improving Hadley's quadrant.—*Peter Dollond.*

1773. A method of securing buildings from fire.—*David Hartley.*

Method of casting and boring iron guns.—*John Wilkinson.*

A method of distilling to save expense.—*Thomas Danforth.*

A new method of bleaching linen.—*Patrick Weldon.*

A method of making lees and ashes from marl, &c. —*John Heys.*

1774. A method of preparing blood for refining of sugar.—*George Fordyce.*

A new method of making coat buttons, &c.—*Isaac Whitehouse.*

A method of printing in designs all manner of silks, cottons, &c.—*Anthony George Eckhardt.*

1775. A method of making needles.—*William Steward.*

1776. A new method of raising tin, copper, &c.—*William Knowles* and *John Hobnam.*

1777. A method of refining the common and the sea salt.—*John Mansell.*

A method to secure shares of lottery tickets.—*William Nicholson.*

1778. Method of covering artificial and decayed natural teeth and gums with a composition.—*Francis Gillanders.*

A method of making buttons of paper japanned.—*Henry Clay.*

A method of preparing metals for making buttons, &c.—*William Collins.*

A method of painting, gilding, and silvering glass.—*John Kent Tarrant.*

A method of plating steel with gold or silver.—*Richard Ellis.*

Method of beautifying and preserving the colour of wood.—*Humphry Jackson.*

Invention of painting, spangling, gilding, and silvering glass.—*J. K. Tarrant.*

Method of reducing malt and hops into a solid essence or extract.—*R. Thornton.*

1779. A method of manufacturing pot or pearl ashes.—*Robert Shannon.*

A manner of securing buildings from fire.—*John Johnson.*

A.D.

1779. The art of extracting tar from coal.—*John Champion, jun.*

The art of making Glauber salt.—*Alexander Fordyce.*

The art of stamping, &c., gauze and tiffany.—*Michael Beagini.*

Invention for casting oval-bellied pots, &c.—*Jonathan Taylor.*

New process for calcining or extracting the sulphur from poor copper and lead ores.—*William Rae.*

1780. A method of making utensils of pure grain tin.—*John Elwell.*

Invention of rendering soap-suds, after being used in scouring, &c., of sufficient efficacy to serve again, and to make soap therefrom.—*S. Unwin.*

Newly improved methods of constructing furnaces or fire-places.*—*James Watt.*

1781. Art of extracting mineral and vegetable alkali.—*Bryan Higgins*, M.D.

A method of dying, staining, &c., beaver and beaver hats.—*Robert Golding.*

A new method of making saddles.—*Joseph Peover.*

Method of extracting tar, pitch, essential oils, &c., from pit coal.—*Earl Dundonald.*

Invention of making brass with copper and spelter.—*James Emerson.*

1782. A method of rendering horses tractable and docile.—*Philip Astley.*

* So stands this entry in the publication of 1799. But, as our readers are now well aware, Mr. Watt's Patent of 1780 was "for a new "method of copying letters and other writings expeditiously;" while his patent "for certain newly-improved methods of constructing fur- "naces or fire-places" was obtained, not in 1780, but in 1785. Probably, *both* of those patents were intended to have been introduced in the list here given, (which was prepared for the use of the Court of Common Pleas); as they both relate to "Methods."

A.D.

1782. A method of making small shot.—*William Watts.*

A new method of making wheels.—*Augustus Newcome.*

New invented processes by which the alkali contained in sea salt, salt water, rock salt, springs, salt cake, Glauber salt, and vitriolated tartar is separated from the marine and vitriolic acids.—*A. Fordyce.*

Discovery of the application of a principle in hydraulics suitable to an hydraulic machine.—*John Richmond.*

1783. Method of making bar-iron from pig, scull, &c. iron.—*Richard Jesson.*

A method of making bolting cloths for dressing flour.—*Benjamin Blackmore.*

A method of making cast-iron malleable.—*George Matthews.*

A method of working cast-iron into bar-iron.—*Peter Onions.*

A method of hardening and stiffening copper, &c. —*John Westwood.*

A mode of constructing spectacles.—*Addison Smith.*

A method of using steam in aid of fire in obtaining salts.—*Robert Vazil.*

A method of hardening and stiffening copper, brass, iron, and steel.—*John Westwood*

Method and process for preparing, welding, and working iron.—*Henry Cort.*

Method of making bars for sash windows, &c., of copper, iron, or any mixed metal containing copper. —*William Playfair.*

1784. A new method of making ropes.—*Benjamin Seymour.*

Method of rearing shrubs.—*Philip le Brocq.*

New method and art of shingling, welding, and manufacturing iron, &c.—*Henry Cort.*

A.D.

1784. Discovery for refining sugar, and making sugar from cane-juice.—*R. Murray.*

1786. A new method of manufacturing looking-glasses.—*Obadiah Westwood.*

Method of securing iron from rust or corrosion.—*William Ker.*

A method of applying springs to saddles, &c.—*Thomas Smith.*

1787. Method of making yeast.—*Richard Tillyer Blunt.*

Method of making white lead by substituting tanners' bark for horse litter.—*Richard Fishwick.*

Invention of a new method for making and manufacturing printing-paper.—*Samuel Hooper.*

Entire new mode, method, or art for preparing, shingling, and welding iron with pit coal, from the ore, by the application of a machine.—*William Purnell.*

Method of raising the supply of oil in lamps—*Peter Keir.*

1788. Method of preparing and restoring the calk of lead after being used in extracting the mineral alkali from common salt.—*Samuel Burnie.*

1789. Method of adapting and conveying the heat from the fire of coal employed in coke ovens for working steam engines, baking bread, &c.—*H. S. Conway.*

Invention of a certain method of tempering all instruments and manufactures of steel.—*D. Hartley.*

Method whereby to produce a rotary motion from the action of an alternate movement in any direction effected by any machine.—*Thomas Burgess.*

1790. A method of purifying malt spirit, and other distilled spirits.—*Bryan Higgins, M.D.*

An improved method of making nails.—*Thomas Clifford.*

A new method of making lead pipes.—*John Wilkinson.*

A.D.

1790. A method of constructing ships or vessels to move without sails.—*Earl Stanhope.*

Method of moving ships against wind, waves, current, or tide, &c.—*Earl Stanhope.*

Method of making punches for punching and stamping matrices for printing-types and other devices, which cannot be counterfeited.—*Francis Bayley.*

Method of preparing oil for making soap.—*Samuel Pugh.*

Invention of running or laying oil colours, so as to preserve their transparency.—*William Dight* and *William Roberts.*

An entire new method in all the essential parts of brewing.—*John Long.*

Certain new methods of making nails and spikes of iron, copper, and other metals, by means of machinery. —*W. Finch.*

1791. A method of using inflammable air for procuring motion and facilitating metallurgical operations.—*John Bowler.*

Method to sustain or resist the weight or pressure of fluids or solids.—*Isaac Mainwaring.*

Method of constructing a steam engine for working mills, for grinding, rolling, cutting, turning any machine that can be turned by water, by a new invented figure called a *sub supra,* &c.—*James Summers.*

New method of tanning skins and hides cheaper and better, and with a great saving of bark.—*John Long.*

A new method of plaining wood, whereby superior accuracy is obtained.—*Samuel Bentham.*

A new method for filtration of water and other fluids.—*James Peacock.*

Method of obtaining from wood ashes a greater quantity of alkali.—*George Glenny.*

A.D.

1791. Method of communicating heat to green-houses, dwelling-houses, &c.—*John Hoyle.*

Method of constructing locks for canals, and improving those already made.—*James Playfair.*

Method of improving the refracting telescope and other dioptrical instruments.—*Robert Blair.*

Method of dyeing woollen cloths, stuffs, and other materials in various colours, and of any figure.—*G. Jeffreys.*

Method of using inflammable air for the purposes of procuring motion, and facilitating metallurgical operation.—*John Barber.*

Method of making from the same materials, and by means entirely new, copperas, vitriol, and different sorts of dye or dying stuff, paints, and colours; and also for preserving ships' bottoms from worms, &c.—*William Murdock.*

1792. An improved method of manufacturing of sal ammoniac, and Glauber and other salts for all commercial purposes.—*William Menish.*

A method of bringing iron ore, and also calx of iron, into a metallic state, without first rendering either of them fluid.—*Samuel Lucas.*

A method of decomposing or removing all sorts of colours in linens and cottons, and for whitening all kinds of linens and cottons in different stages of the paper manufactory.—*Clement Taylor.*

A mode of applying ropes to the purpose of drawing or raising coals, lead, tin, or other minerals out of mines, &c.—*John Curr.*

A method of changing the smoke or vapour arising from the combustion of many kinds of substances, &c.—*Charles William Wood.*

New method of bending timber, whereby the grain is preserved, in circular work.—*John Vidler.*

A.D.

1792. Method of depurating and improving animal oil.—*Charles Gower.*

Method of separating iron from iron-stones, and smelting it.—*William Fullarton.*

Improved method of making sal ammoniac, &c.—*William Menish.*

New method of making cast metal or pig-iron from the ore.—*John Wilkinson.*

Method of changing smoke or vapour into various useful materials.—*C. W. Ward.*

Method of separating mineral alkali from common salt.—*George Hodson.*

Invention of a plan or method of supplying canals, &c., with water.—*John Longbotham.*

Method of dyeing, staining, and colouring beaver and beaver hats.—*Robert Golding.*

Method of fusing ores, metals, and calx of metals. —*Edward Lucas.*

Method of smelting and purifying fossil coal, iron-stone, iron ore, by steam, air, and fire, and impregnating the same with inflammable air, producing thereby a tough metal.—*John Barber.*

1793. A new method of preserving animal and vegetable substances.—*John Donaldson.*

Modes of conducting and generating steam, and saving fuel, by applying the principles to steam.—*John Dale.*

Invention and method of warming rooms and buildings with hot air of more pure quality.—*Joseph Green.*

Method of preparing linen and cotton cloths with a paste, so as to form a smooth and regular surface for printing on.—*F. F. Eckhardt.*

Method of preparing and printing paper in different patterns, &c.—*F. F. Eckhardt.*

A.D.

1793. Method of constructing canals without the use or necessity of locks.—*Joshua Green.*

Method of raising, removing, and delivering earth, stone, coal, water, &c.—*Joseph Sparrow.*

Entire new mode of manufacturing nails of every kind by machinery.—*Thomas Clifford.*

New method of making fire-irons.—*General S. Bentham.*

1794. Method of tanning hides and skins by means of metallic calces.—*Samuel Aston.*

Method of making leather and various other articles water-proof.—*John Bellamy.*

An improved method of constructing navigable canals without the use of locks or inclined planes.—*Edward Rowland* and *Exuperius Pickering.*

Method of preparing rag for paper.—*Wm. Cunningham.*

Method of preparing allum and other salts.—*Earl Dundonald.*

1795. Method of applying the use of animals to machinery.—*A. G. Eckhardt.*

A new principle for the formation of bricks.—*Edward Cartwright.*

Method of tanning leather.—*John Tucker.*

Mode and manner of making, uniting, and applying cast-iron blocks to be substituted in lieu of keystones, in the construction of arches.—*Richard Burdon.*

Method of bleaching paper in water leaf or sheet, and sizing it without drying.—*Elias Carpenter.*

Entire new mode of bleaching paper.—*John Rigg.*

Horizontal windmill upon entire new principles.—*Daniel Mariner.*

Method or methods for disorganizing and obtaining the mineral and vegetable alkali.—*Earl Dundonald.*

A.D.

1795. New method of performing and facilitating the business of divers manufacturing, economical processes. —*General Bentham.*

Method or methods of preparing salts or saline substances for manure, &c.—*Earl Dundonald.*

Method of making needles, bodkins, fish-hooks, knitting pins, netting needles, and sail needles.—*William Bell.*

Method of combining timbers applicable to the improvement of naval architecture, and all ponderous and large works composed of wood.—*Charles Wilson.*

1796. A method or plan for detecting errors in accounts of all kinds.—*E. T. Jones.*

Method of separating beer from yeast, and preserving the yeast for any length of time.—*Felton Matthew.*

Invention and discovery of extracting starch from horse-chesnuts by a new and simple method.—*Lord William Murray.*

Method or process for tanning hides and rendering them more solid and incorruptible.—*William Desmond.*

An improved and expeditious method of making and manufacturing horse-shoes, &c.—*Wm. Moorcroft.*

A method for extracting and making from vegetable bodies an astringent acid liquor, and an empyreumatic oil for dressing leather, &c.—*Josiah Hately.*

New invention in the art of constructing bridges, aqueducts, &c., peculiar constructions for wood and iron bridges.—*James Jordan.*

Method by which houses, and other buildings, of any description or dimensions, might be erected in an entire mass or body.—*Henry Walker.*

An art or method of manufacturing or making a certain composition stone for mill-stones, &c.—*Major Pratt.*

A.D.

1796. Improved method of retaining cotton, tobacco, hemp, &c., in nearly the same compass in which they can be compressed.—*William Sabatier.*

Method of weaving linen, cotton, woollen, and worsted cloths, by means of looms wrought by water or by any other power.—*Robert Miller.*

Method of making and working presses of all kinds and dimensions, and particularly packing presses and hot presses.—*Isaac Waldon, John Bowler.*

Method of making British pot-ash, for the use of all kinds of manufactures in which foreign pot-ash, or any alkali, is useful.—*Richard Hoakesly.*

1797. Method of constructing bridges of plate iron.—*John Nash.*

An improved method of condensing and cooling spirits by means of machinery, not before used for that purpose.—*J. F. Atlee.*

New method or methods of making ceruse or white lead.—*Earl Dundonald.*

Method of making soap, and bleaching by means and use of mineral and vegetable alkalis.—*John Crooke.*

Improved method of preparing indigo for the purpose of dyeing.—*Joseph Barlow.*

Certain new methods of retaining, clarifying, preserving, and drawing off all sorts of liquors, particularly malt liquors, &c., together with sundry improved casks and implements, &c.—*Joseph Bramah.*

Method of obtaining the fossil alkali from several of its chymical combinations.—*George Hodson.*

1798. Method of destroying the colouring elements and particles in coloured rags.—*Hector Campbell.*

Method of working pumps by sea or land, rubbing boards used in bleaching, and all other mechanical machines of similar natures, by means of a cylinder, &c.—*William Fulton.*

A.D.

1798. Certain new methods of producing and applying a more considerable degree of power to all kinds of apparatus —*Joseph Bramah.*

Method of laying, twisting, or making ropes or cordage.—*William Chapman.*

A method, by the application of which, all vessels may derive durability, soundness, &c.—*A. Bosquet.*

Method of improving the processes of brewing, distillery, boiling, evaporating, raising, applying, and condensing steam or vapour from aqueous, spirituous, saccharine, saline, and other fluids.—*Richard Shannon.*

END OF THE APPENDIX.

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